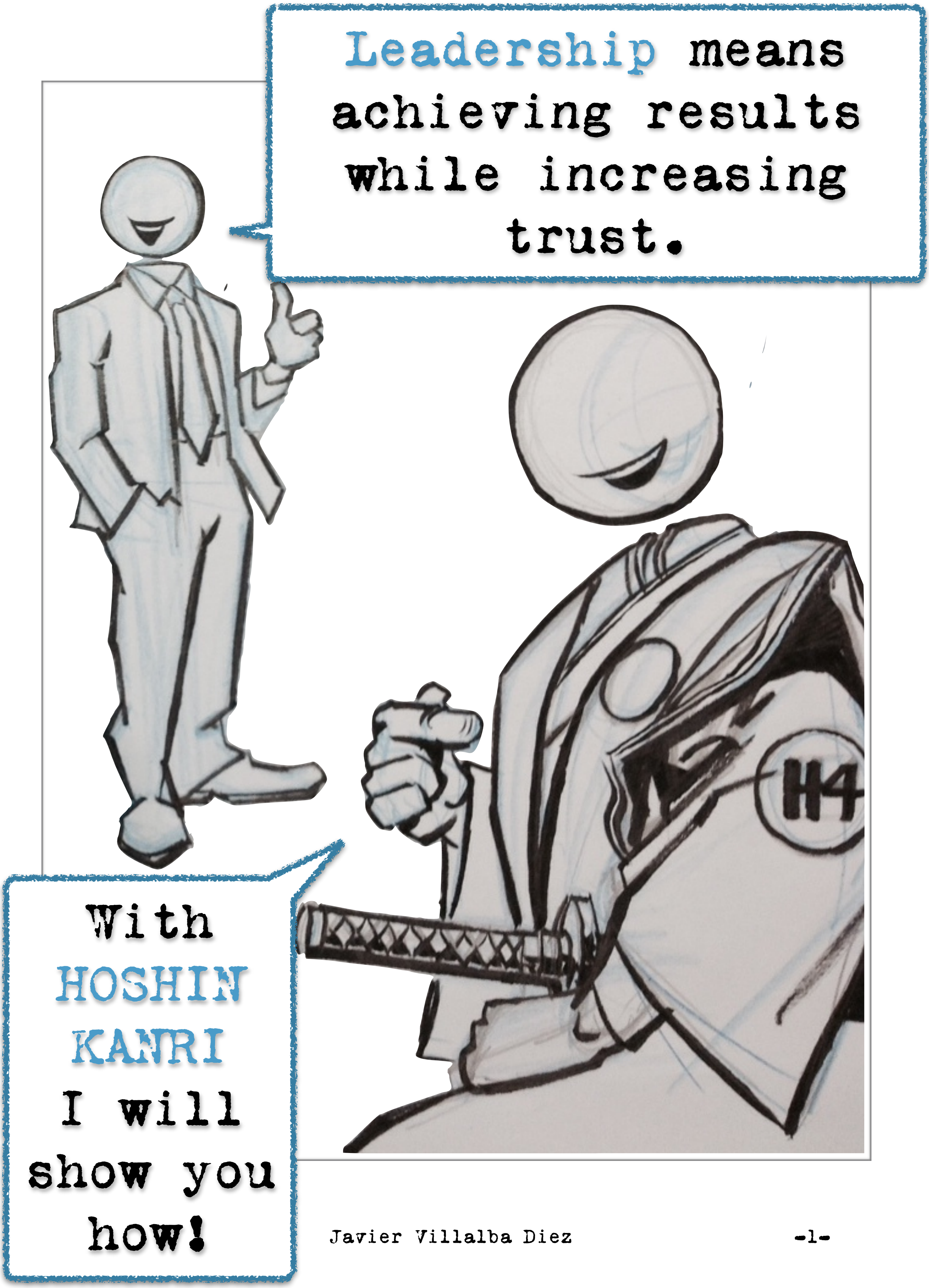

Leadership means achieving results while increasing trust.
With HOSHIN KANRI I will show you how!
H4

Author. Javier Villalba Diez
Sensei. Dr. Joaquin Ordieres

PhD Program Industrial Management
Hoshin Kanri.
Principle Centered Leadership

Citation BIBTeX format:

```
@techreport{jvillalba-diez2014TFM,
    title = {{Hoshin Kanri. Principle Centered Leadership}},
    author = {Javier Villalba-Diez},
    group = {TFM},
    year = {2014},
    institution = {Technical University of Madrid, Department of Industrial Management},
    month = {06},
    Date-Added = {2014-07-29 10:05:52},
    URL = {http://oa.upm.es/...}
}
```

Table of Contents

I. Foreword

The writer writes.

If someone wants to learn how to write, that person could get to be a person that writes, but will never become a writer. I am then a writer because I write.

I would need to know if I write well and if I have style. Style cannot be taught, learned or found. You have it or you don't have it and you don't know why. The intimate lack of respect I feel for myself feeds my self criticism. If I find this manuscript mediocre or rubbish, then it will never know the elegance of helvetica or the vulgarity of any other typography. Probably only Paloma will read it, some friend, maybe my son. But in fact, it is enough with Paloma. I write because of her and for her.

I have imposed myself a mission. I want to wake in you, occasional reader, the twinge of lucidity. Without limits and without compassion.

One knows but forgets that one knows. That´s the way to handle lucidity. But things get tough when one cannot forget. The awakening to lucidity might never happen but when it happens, if it happens, there´s no way to avoid it. And when it comes, it stays forever. One understands that in nature there is no cause and/or effect, no goals and no progress. One understands, although not accept, that life is born with death sticked to it, that there is no succession of events, they happen simultaneously and they are inseparable. The only thing we own is our illusion and that´s what moves us. Lucidity is a gift and a punishment. Lucidity comes from light. And so the one that generates light, the one that brings the light that enables introspection is lucid. Lucidity is painful. Like a sting. The only pleasurable experience is that of being conscious of one´s own lucidity because it brings with it the silence of understanding.

Madrid, München, Tokyo June 2014

I. Abstract

The purpose of this paper is to sketch the outlines of what will, hopefully become my PhD thesis: the proposal of an evolutional leadership behavioral pattern, Hoshin Kanri, that enables process owners in organizations attain alignment by achieving their goals while increasing trust.

I intend to develop such a behavioral pattern or "proper way" 善道[1] by adopting a network perspective over two organizational dimensions: process dimension and process owner dimension. In both dimensions I will propose measures of their topological structure and functionality. From there I will propose quantifiable characteristics that will help me enunciate several hypothesis about their dynamical and evolutional characteristics. I intend to test these hypothesis in the field and report the results to enable others to challenge this research.

[1] 善道 [ZEN DOU] from japanese "proper way"

II. Lean Management and Leadership.

My favorite definition of leadership is given by (Covey et al., 2008): "Leadership means achieving results while increasing trust".

Leadership has become increasingly popular lately because, as the world gets more and more complex (Mitchell, 2009) the rules of nature are more and more visible and so we have the need and urge to understand[2] our nature and reality around us for pure survival reasons.

Leadership theory is a multifaceted conglomerate that has evolved, emerged, served ideologists since human kind has collective intelligence. It has been shaped by power through myths, tales and stories to explain how the proper way "道" to guide a collectivity to attain certain goals.

I have studied leadership for years and, maybe because of my biography and the years spent in Japan as a production manager, I tend to relate the concept of leadership to the Bushi-Do (武士道) (Tsunemoto, 1979) or "the way of the warrior". I hope you can apologize this bias. "Way" (道) should not be understood as "path" but as "way of doing things" or "behavioral pattern".

I will argue in this paper why and how I believe that the only purpose of the Lean Leader is to make sure that everyone, everyday, the whole day practices proper PDSA,

[2] The word "understand" has different semantical origins in different cultures:
- in english, "understand" something means to stay on top of it,
- in german, "verstehen", similar as in spanish, "comprender", understand means embrace,
- in italian, "capire" means have something in your head,
- in japanese, "分かる" - WAKARU - has the kanji "分" meaning divide the unknown from the known.

so, I use the word understand in the japanese sense.

the 改善道 (the behavioral pattern of performing continuos improvement).

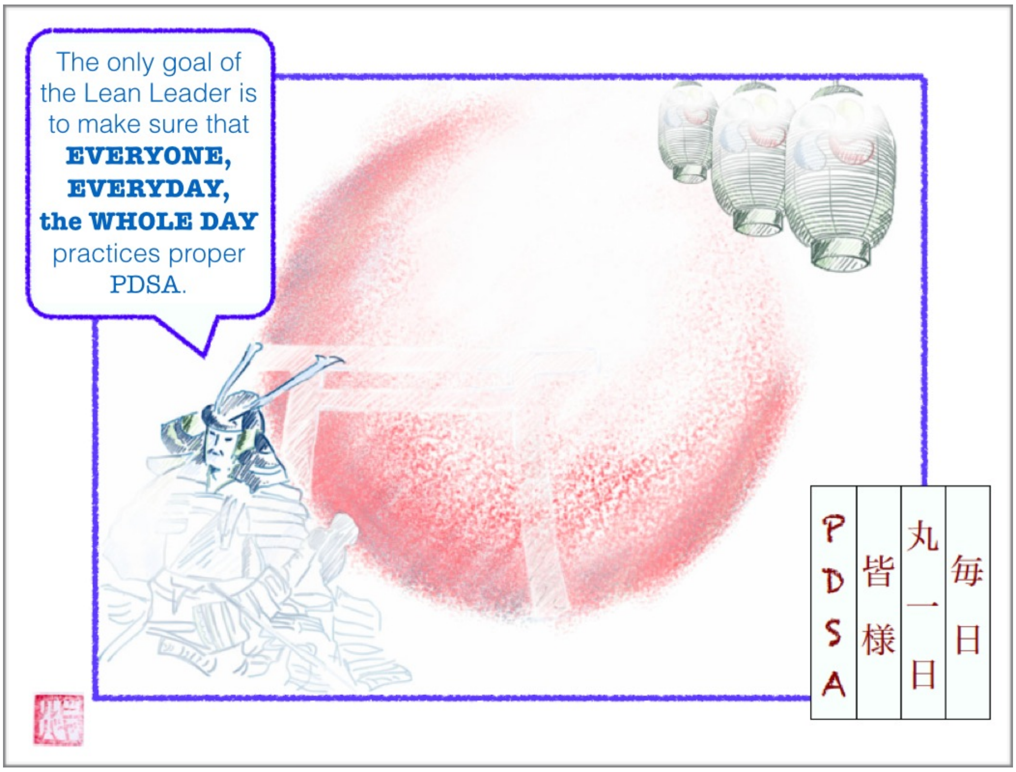


Figure 1. The Role of the Lean Leader (Villalba-Diez, 2013a)

There is an extensive and intensive Leadership´s body of knowledge, and although I do not intend to make a closed classification of it here, we can cluster this "leadership theory" in different classes:

- Spiritual Leadership. Leadership aims to influence people´s souls but not control them (DePree, 2004) (Etzioni, 1994) (Fairholm, 1997) (Zohar, 2000). This last reference is a wonderful book about the one very powerful concept of spiritual intelligence and its social and neurobiological implications.
- Servant Leadership. Servant Leaders build up a community out of empathy, understanding and listening. They serve the stakeholders (Greenleaf et al., 2002) (Frick, 2013).
- Holistic Leadership. The Holistic Leadership by Wheatley (Wheatley, 1992) postulates that Leadership is contextual and systemic. Leaders promote organizations where continuous

learning can be lived and fostered (Senge, 1990). For Senge, Leaders have three roles: design, guide and teach.

- Leadership as Art. Leaders execute discrete actions that embrace all processes they touch (Mintzberg, 1998) (Vaill, 1991) (Vaill, 1996). Strategy emerges from the situative leader´s actions (Mintzberg, 1985). The metaphor used is the orchestra director.
- Leadership based on Results. Here Leader´s character is tagged through the results the leaders achieve (Ulrich et al., 1999) (Wakeman and Winget, 2010). Effectiveness is the name of the game.
- Strategic Leadership and Management. Leaders in the view of a giant of management theory such as Peter Drucker (Drucker, 1954) are responsible for the well being of all stakeholders that relate to the organization, both internal such as employees or management, and external such as customers, government and even the community. Around this fundamental backbone, there are many other scholars building methods that support this view (Neßler and Fischer, 2013). John Kotter in his landmark book about leadership and change management (Kotter, 1996) understands the leader as the one group of individuals that enable alignment in the organization by empowering and inspiring others.
- Visionary or aspirational Leadership. For Kouzes and Posner (Kouzes and Posner, 2012) the leader inspires her subordinates by proposing a vision that serves as a compass that "mobilizes" the energy of the organization in order to unite forces for a common goal.
- Leadership based on competence. For Walter Bennis (Bennis, 1993), those individuals with extraordinary competencies in the organization should teach others increase their skills.
- Charismatic Leadership. In this view of leadership, proposed by (McCann et al., 2011) (Avolio and Yammarino, 2013) (Conger and Kanungo, 1998) subordinates in the organization perceive certain extra-ordinary traits and attributes in the leader basing these on empirical observation, psychoanalysis and "social contagiousness", creating this way a pull and gravitational head for the subordinates to follow.

- Transformational and Value based Leadership. In this view of leadership, the organizational agents grow as individuals and subjugate their personal interests to the organizational goal. Leaders and followers increase their game recursively by empowerment and support each other in order to achieve better moral and motivational levels. Examples of this perspective can be found in (DePree, 1992) (Fairholm, 1991)

An excellent Leadership review can be found in (Fairholm and Fairholm, 2009) in case the reader wishes to expand her knowledge in this matter.

Lean Management formulates a socio-technical multidimensional problem: how to systematically get rid of non-value adding activities in value-streams. A value-stream is a concept described in (Rother et al., 1999). Womack and Jones (Womack et al., 1990) (Womack and Jones, 1996) popularized the concept of Lean Management in the western world in the 1990´s with their systematic study of Toyota´s astonishing sustainable success. Although it is widely accepted between scholars that Lean management practices increase performance in organizations (Krafzik, 1988) (Wood et al., 2004), there are few serious research that study lean practices and process / performance improvement. Here we list few noticeable exemptions:

- the good correlation review of lean practices and performance offered by (Shah and Ward, 2003),
- the amazing, almost compulsory book for any lean practitioner, engineer or learner of industrial and process management by W. Hoop and M. Spearman (Hoop and Spearman, 2011),
- an attempt to find a common understanding on concepts and measures of lean management (Shah and Ward, 2007),
- a meta-analytic investigation about the impact of Just in Time on process performance (Mackelprang and Nair, 2008),
- the implementation of lean practices to knowledge work shown in (Staats et al., 2011) building on Drucker´s "knowledge worker" (Drucker, 1999), or the application of lean to health-care processes (LaGanga, 2011) showing the universal-

ity of lean practices for all sorts of value-streams (Sousa and Voss, 2001),

- (in japanese) the great case study on PDCA and its impact on TPM (total productive maintenance) by Baba-san (馬場文雄, 2012)
- and the more recent study of how environmental complexity effects the dynamism in lean practices (Azadegana et al., 2013)

Several authors / consultants started with a more commercial approach looking at lean with the leadership lens after Jeffrey Liker (Liker, 2004) describes what he called the 14 "Toyota Way" "principles". I quote the word principle here, because it can be misleading. When Liker lists the 14 "principles", he writes down 14 management practices that helped Toyota and that should help increase the "lean-ness" of others organizations. Well, a practice is not a Principle. There is extensive literature on leadership that supports this statement, and a supreme exponent is (Covey, 1989). A Principle, unquoted, is an unmovable truth that is timeless and operates regardless of the organization, individuals or whatever other factor. Liker´s "principles" are values. Values are interpretations of timeless principles that are made by specific organizations or individuals, again backed up by (Covey, 1989). Nonetheless, Liker list of values is clearly formulated and correlates to other research of lean practices (Cua et al., 2001) (Staats et al., 2011).

Fueled by Toyota´s remarkable success, Lean Management went hype. Literally, everyone tried to copy what Toyota was doing however with little understanding of why they were doing it, and more importantly how had Toyota come to the idea, of doing things that "way". Consultant industry took over and scholars such as Liker (Liker and Meier, 2006), Jones, Rother (Rother et al., 1999),(Rother and Harris, 2001) (Harris et al., 2003) (Jones, 2011) (Smalley, 2004) (Wiegand and Franck, 2005) started instrumentalizing university facilities to market consultancy quick fix methods for deep rooted problems.

Paraphrasing Henry D. Thoreau (Thoreau, 2004), there were (and are) thousands hacking the branches of evil instead of fostering deep understanding of the root principles. Those methods helped the industry increase awareness about the waste structure of processes and certainly raised the game, however I believe that most of those books should have had as first sentence something like this:

CAUTION!
This information can be hazardous for the survival of your organizations!

This method oriented view was certainly not incorrect, but it was incomplete. In the following paragraphs I will present some examples of why.

1. Liker´s Toyota Production System House.

Let´s take Liker´s concept, borrowed presumably from Toyota, of "Toyota Production System House" (Liker, 2004). Something to build. A solid structure, just as the western manager wants it. Something that an organization should work on in order to be successful. I believe this picture is fundamentally wrong and collides frontally with the idea of continuous improvement (Ohno, 1988). A house is something you start building and when you end, you feel comfortable and cozy in it. Isn't is what everyone wants? A solid place where to be safe from all that turbulent "out-there" that would stand straight after any storm.

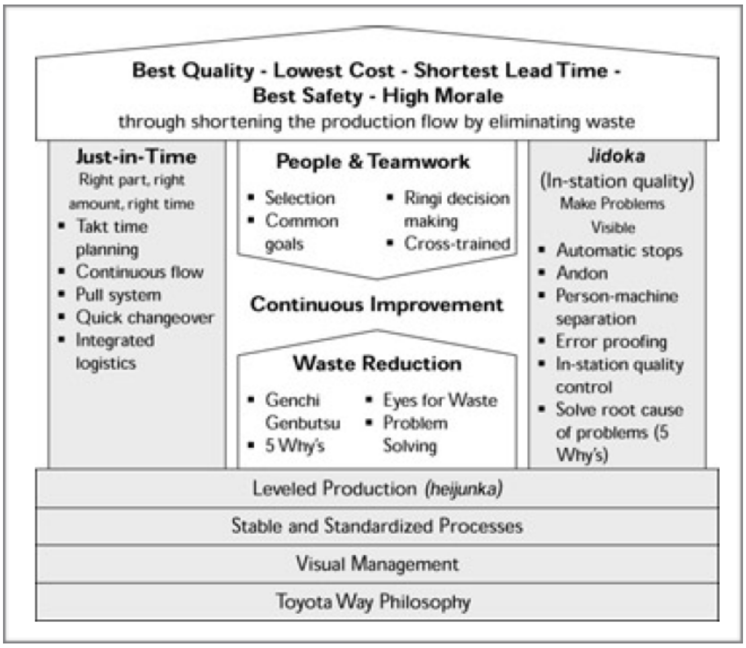


Figure 2. The Toyota Production System House (Liker, 2004)

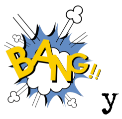
To believe that a successful living organization (resilient and evolvable) (Darwin, 1859) can be pictured through a stable monolithic greek-temple-looking structure is wishful thinking (Lewin, 1992).

Of course many decision makers bought in. The idea was easy to understand and easy to communicate. But, do you know the three pigs tale? Well, there are always nasty wolfs out there to blow any House off, no matter how solid. The undeniable and ruthless persistence of evolutional laws (Darwin, 1859) are one of those wolfs. No matter what we would like to believe, or how we would like the world to be. What are the survival chances of a rigid system in an ever changing environment? (Vaill, 1996). Exactly, as evolution has shown for the last thousand of millions of years: ZERO.

For securing survival of organizations, the management of complex systems needs to foster evolvability and resilience (Smith, P. et al., 2011) properties (Rubinov and Sporns, 2010) in the organizational structure and functionality rather than a stable sound ground (Schuster, 2009).

2. Rother´s Value Stream Future States.

Another example. When Mike Rother landed in the Fraunhofer Institute IPA in Stuttgart Germany and took a sabbatical year for researching on lean management in Europe, he maybe didn´t know the implications of his work. As a superb communicator and marketer, he brought up the concept of value-stream mapping in a very fashionable and understandable way.(Rother et al., 1999). First create a "current state" map of the processes, then create a "future state" following certain rules, then make a plan to move from the current state to the future state.

The meta-level of this is again simple as a pimple: Bring a simple idea, easy to understand, explain it so that everyone understands it, and 

you are in for some big consultancy bucks.

But, you know what happened? Well, organizations and process owners behind, bought into this idea so fiercely that they started making value stream maps all over the place (some are still doing it). Rother and his colleagues challenged the rim and they got it rolling and focussed on value streams, that was good. What Rother and Co. didn´t explain were the implications of acting upon many inter-dependent value-streams at the same time (Beinhocker, 2006). The result is also simple to explain: plain chaos.

For example, I can tell you something that happened to me while being production manager in Japan right after the financial crisis in 2008. When the controlling department of the one organization I worked for discovered they needed to achieve a 20% cost reduction, they made a current state value-stream, a future state value-stream and of course a plan to achieve it. One of the activities set in the plan was that personal costs were too high. This was communicated to HR who also made a current state value-stream, a future state value-stream and a plan to support the cost reduction goal, so HR decided to increase the external quote of blue collars by 30%. This had almost instantaneous implications on performance, and myself, the process-owner, had a workforce turnover increased by 200%!. My Quality-Costs sky rocketed and the quality department (who was also working on "smart" future states) informed the controlling department that we were losing around $1 Million on Warranty-related issues every single day!!! What did controlling do? Incredibly, they continued with their "smart" future states and kept on forcing the organization do something AGAINST its own interests!

Indeed paradigms, once set are difficult to kill! What was really happening is that the intimate (and obvious) inter-correlation between processes had been overseen because everyone was too busy implementing their "future states". We ended, as organization, literally not knowing what was up or down as in Escher´s Relativity famous lithograph.

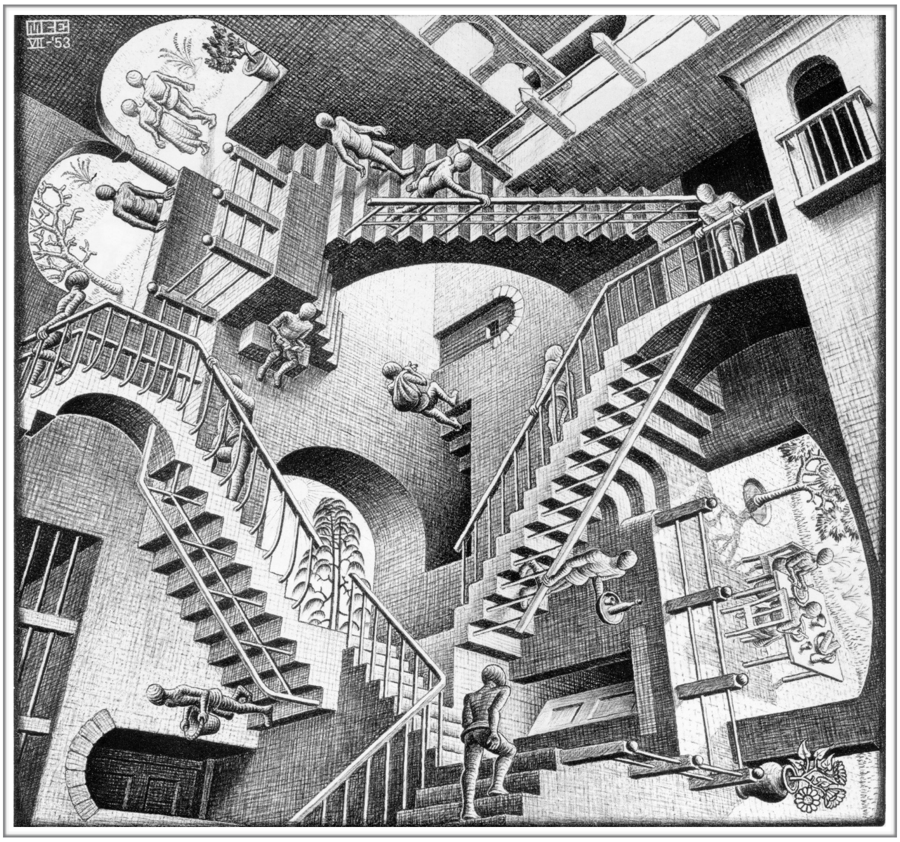


Figure 3. Relativity (Escher, 1953)

In the same line, we can find another example in (Rother, 2009), and I will argue later why.

My reading of this is that there seems to be a pattern that repeats itself in this lean-made-easy industry. And is the pseudo-scholar presentation of partial concepts to the public for the sake of making them easy to understand (and to market).

What seems obvious is that it is very dangerous to set false pictures in the head of leaders, because they will make wrong choices and the implications can be horrendous.

Brain research has recently discovered (Goldberg, 2009)(Keltner et al., 2010), that there is a region of the brain called orbitofrontal cortex (OFC) in which morale seems to be placed. If this region does not get enough nourishment, because the brain needs the resources to deal with other more acute stimuli, then the human brain is not able to act following a moral code. It happens for instance in war where humans are able to commit atrocities, and it can also happen in business situations when decision makers are subject to long lasting amounts of stress. The orbitofrontal cortex does not get enough resources, and stops partially or totally its functionality and hence, the individual acts with a-morality.

Brain and behavioral researchers (Gruenfeld et al., 2003) show empirically that power deforms the brain. In fact, patients with orbitofrontal cortex damage behave very similarly as a large amount of people in power positions. Power-needs of leaders could eventually make them unable to act with morality because their orbitofrontal cortex stops functioning correctly. These are just empirically demonstrated neurobiological facts.

If power deforms the brain and influences the decision making of an individual through the allocation of resources, why then not extrapolate to the organizational level and state that power dynamics shape organizations. This is idea is not new and was proposed by (Rao et al., 2000).

The magnificent research and review on organizational power politics by Gilbert W. Fairholm (Fairholm, 2009) describes perfectly the ubiquitous nature of power in organizations. Power dynamics are everywhere in organizations, like a gravity field acting upon all its agents, and the consequences of ignoring power would be fatal. In Organizations, sociologically, individuals use power to achieve their intended results (Granolati and Stupak, 2002). In fact, if leadership is about achieving results while increasing trust (Covey and Covey, 2008), then power and leadership are fundamentally linked at its roots. Individuals blinded by power are un-able to lead in the sense of "achieving goals while increasing trust" because their will consistently put their own power-needs before their organizational needs. To put it in one sentences:

Power-needs of organizational leaders are the reason NR. 1 why lean activities are unsuccessful.

Power is then a central topic in organizational theory, nevertheless, scholars are spending relatively little time in understanding how power is used by organizational agents. Practitioners are however constantly engaged in such a kind of interaction. This is the reason why we need a definition of organizational power.

I will use - recursively in this paper - the network perspective to look at the organization, and from there will say that power is, roughly speaking, the capacity of an individual to allocate the necessary resources that enable her attain certain desired results. When resources are scarce, a value-creating oriented organizational network´s agents are in a constant struggle for resources. Power dynamics emerge from such resources "kampf".

My prefered view on leadership (Covey, 2004) is built from the bottom up. The leader first needs to be trustworthy on a personal level. This means that she needs to have a balance between her character (who she is) and her competence (what she can do). Once the leader is trustworthy can then create sustainable relationships of trust with others. It is impossible to sustain trust without trustworthiness. Once the leader has created a relationship of trust with others in the organization, she can start with her empowerment mandate on the managerial level. It is not possible to empower someone without having built a trust relationship with her. Once the leader has attained a desirable level of empowerment, she can try to reach alignment at the organizational level. It is not possible to achieve alignment at the organizational level without certain levels of empowerment in the organization. This argumentation resembles an agenda to attain a common goal while increasing trust, an agenda of leadership, the Leadership Path Bushi-Do (武士道).

I understand following previous statements to be self evident, and will not try to clarify them further:

1. It is impossible to build trust without trustworthiness.
2. It is impossible to enforce trust.
3. It is impossible to attain empowerment without trust.
4. It is impossible to enforce empowerment.
5. It is impossible to attain alignment without empowerment.
6. It is impossible to enforce alignment.

And you can add another corollary to all those 6 self evident truths: regardless of the amount of power that the leader has.

This is why leadership scholars (Covey, 2004) (Fairholm and Fairholm, 2009) and many others state that Leadership is not a matter of position or power, is a matter of decision. It starts from the inside out, built on the balance between character and competence (trustworthiness) the ladder up to organizational alignment.

The challenge I propose with Lean Leadership is far from the n-th commercial, quick fix, solution oriented approach that might ruin such a complex topic (Liker and Convis, 2011)(Kudernatsch, 2013). It is more humble and less glossy.

The challenge that lies ahead can be explained in two steps in my opinion:

1. First. I want to find a way how to match the holonic or fractal nature (Iordache, 2010) of processes into the euclidean topology of a hierarchical organization, and understand what changes are necessary to be made on both process structure and organizational topology in order to foster sustainable value creation.

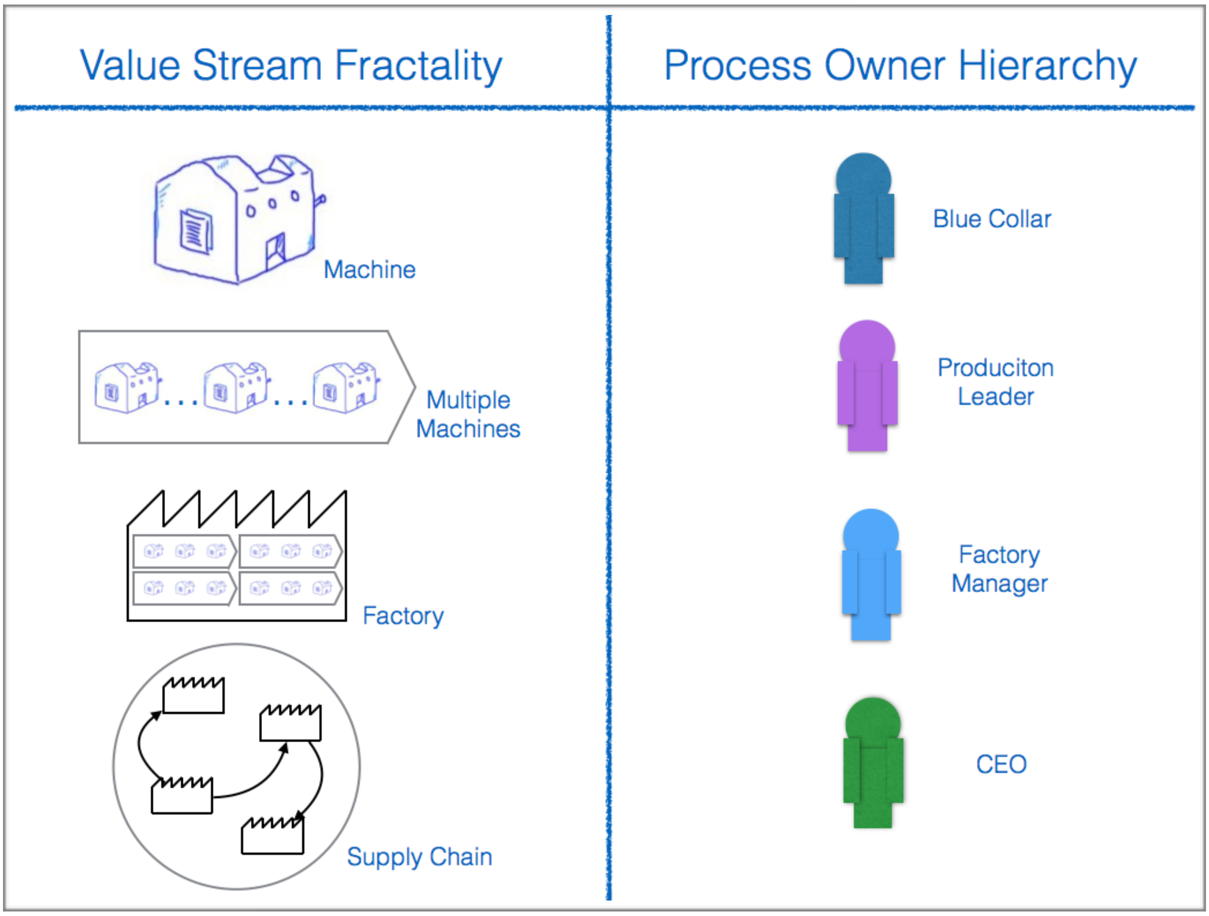


Figure 4. Value Stream oriented fractality and Process owner hierarchy.

2. Second. I aim to propose models for understanding and managing the non-linear complex dynamic interactions within human hierarchy and the process structures these process owners manage.

In other words. Through the re-framing of an old concept such as Hoshin Kanri, I propose a radical re-thinking of lean management. Not only we need new practices. We need a re-thinking of organizational topological structures that sustain the ever increasing complexity, as defined by (Johnson, 2011), these same organizations face.

III.State of the Art.

A. Process Management

A process is a sequence of interdependent steps which at any stage consume resources to transform an input into an output. This output serves as input for further processing and is at the same time a constraint for the input as well. This output is of value for a certain customer, hence a process can be understood as a value stream.

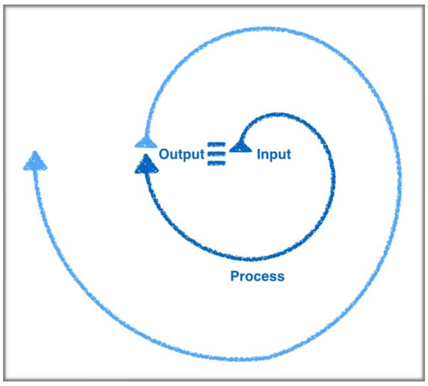


Figure 5. Spiral Paradigm of a Process.

An example of this definition, for visualization purposes, could be a factory. Raw materials are transformed into products of value for a certain customer throughout a sequence of steps that resemble the value stream. The quality of the output will be crucial to ensure that the cash-flow cycle is closed and the factory can buy more raw materials and hence ensure further production.

Lean Management Literature dealing with the managerial approach to improvement, for instance (Imai, 1986) and more recently (Liker and Maier, 2006), (Dennis, 2006) or (Sobek II. and Smalley, 2008), focuses almost solely on empowering individuals for more effective and efficient problem solving techniques. The Manager is compelled to solve problems faster, with less resources and make sure this problems never occur again through proper standardization. In order to achieve this, these scholars propose, more or less explicitly, a standardized "problem-solving" method such as PDCA (Plan-Do-Check-Act) (Sobek II. and Smalley, 2008) that would enable process owners to systematically "kaizen-ize" their problems away.

A development in this approach was later taken by Rother with his KATA (Rother, 2009) in which, a supposedly Toyota Motor Corporation´s specific behavioral pattern is proposed for process owners to behave in order to foster the empowerment of the agents in the organization. The step given, based on brain research (Coyle, 2009), is crucial and double. Firstly, Rother puts the focus on the process management and calls for stopping the branch hitting all that problem solving was about. Secondly, he does it elegantly proposing a standardized way to do it.

Let´s focus on the first part. Process Management. This issue is crucial because it affects the role that Leaders take in organizations. The process owner, that has the responsibility to guide the process to successful ends, is given the role of "empowerer", this is, the one that is successful by making his team members and other fellow-stakeholders successful. The best managers are no longer those that best solve problems, as proposed in (Senge, 1990), but those that best empower their organizations and guide processes holistically to success.

Now let´s have a look at the second part of Rother´s work, the standardization of the process management business approach. The question of why the repetition of routines in order to learn is explained throughly in by Coyle (Coyle, 2009). Now I will focus on how Rother standardizes this approach. The Standard proposed to be repeated or KATA, from japanese "routine" as he calls it, is as follows:

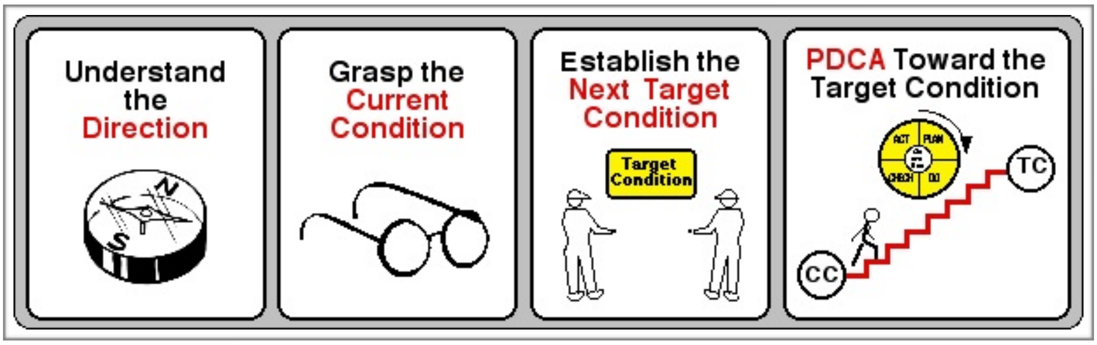


Figure 6. KATA (Rother, 2009)

Extensive Management literature backs up this judeo-christian teleological thought embedded into occidental culture of first plan and then act (Maynard, 2010)(Fogg, 2010). But the truth of the matter is that planning forces process owners to confront a future they can only guess at, as other serious scholars are starting to acknowledge (Martin, 2014). But this is not new. Back in 1985, Mintzberg (Mintzberg, 1985) carved out the concept of "emergent strategy" in contrast to "deliberate strategy". The geniality of Rother resides upon recognizing that a behavioral standard is needed, but the standard he proposes has a fundamental flaw in my opinion, and this is step 3 "establish the next target condition". Evolution, based on patterns, works acting, not planning (Darwin, 1859). Evolution is an emergent process that can only be guided, cannot be planned (Johnson, 2002). There are no "future states" involved (Rother et al., 1999). This KATA as described by Rother, with it´s "we are here" and "we want to be there" fueled by "target conditions" is in my opinion an incomplete frame of thought to be successful at the organizational level.

The more shintoistic (Stiskin, 1972) pattern I propose, based solely upon the need to improve the process and our understanding upon the current state of reality is described as a new form of PDCA as follows:

A lot has been written about PDCA also called PDSA (plan do see act) since Edward Deming popularized it as Shewhart Circle (Deming, 1964). I understand however the PDSA pattern to be a process management oriented way of communication between process owners. My understanding of PDSA is based on following algorithm:

1. See or Check. Go and see the process and establish a process KPI (Key Performance Indicator) that measures process performance. Measure the current state of this KPI.
2. Plan. Grasp the current state of the process (value stream), prioritize the main sources of MUDA, MURA and MURI (Ohno, 1988), the 3 M's, and analyze then main source of the 3 M's.
3. Do. Work on the process to eliminate the main source of 3M's.
4. Repeat 1. to 3.
5. Act. When you have reached a plateau and the process can no longer be optimized without further investment or effort, create a Standard, understood as best known way to do things.

Hence, in my understanding, the algorithm of PDSA is not PDSA but S-P-D-S-P-D-S-...- A.

Notice that there is not a "target condition" as such, and there is no "future state" as stated by (Rother, 2009). The only fundaments we have are, both are solid as rocks:
1. our will to do KAIZEN (Imai, 1989) and
2. our understanding of the current state of the process.

These two are the principle, meaning timeless and universal, based (Covey, 1991) motivations for improvement.

This behavioral pattern can be used to link organizational network's agents that report to each other on several selected KPIs. This way we link one PDSA, one Process owner and one KPI. In this logic, each PDSA helps manage the process through one KPI and is the standardized communication way that connects the organizational network agents and enables fractality. The process owner has the responsibility over her process and the PDSA that is coupled to it.

It is important to remark here, that PDSA is not only the structural unit that enables fractal and non-linear growth. It is also the behavioral pattern that enables the iterative optimization of processes, and is also the standardized communication pattern between the agents of the organizational network.

In this logic, the process owner has the responsibility over her process and the PDSA that is coupled to it. This logic is in conflict with so called "Improvement Suggestion System"[3] (Brinkmann, 1992) that manage the ideas of process owners. The reason for this is that under this system, a process owner is responsible for her process in the organization and with help of the PDSA, will be able and will be compelled (as part of her job) to continuously develop and improve the process under her responsibility.

It is important to remark here, that PDSA is not only the structural unit that enables fractal and non-linear growth. It is also the behavioral pattern that enables the iterative optimization of processes, and is also the standardized communication pattern between the agents of the organizational network.

In fact, this logic, based only on KAIZEN (Imai, 1986) and the current state of reality is so universal that I propose can be applied to any process in nature. Take for instance the "WHOLE PERSON´s PARADIGM" that Stephen R. Covey (Covey, 2004) proposes for people: Body-Mind-Heart-Spirit. The algorithm of PDSA, as previously described, can be applied to each one of this dimensions of the "Eco-System" Person and empower her achieve an ever increasing well being.

[3] In german "Verbesserungsvorschlagswessen"

Figure 7. Whole Person´s Paradigm (Villalba-Diez, 2013a)

The main question that we ask in the next section is if there is an optimal number of KPIs to be reported by these agents. In other words, what is the carrying capacity of connectivity that an organizational network can "digest" in order to ensure a clean standardization process.

B. Chaos Theory and Standardization

1. State of the Art

An Organization is a model-forming, dynamical system and its coherent spatiotemporal trajectories - Organizational behavior - are its Mind (Covey, 2004). The principles of self-organization provide the linkage across levels in the organization (Johnson, 2002). These principles encompass spontaneity, attraction, repulsion, broken symmetry, intermittency, crises, instability, transitions and synchronicity, phenomena that can be clothed mathematically. In the end, it is the cooperative action of multiple organizational network agents that create dynamic patterns that enables value creation in the Organization. It is the intention of this article to bring some light into these dynamics by trying to derive from chaos theory, how many KPIs are the maximum that an organizational network can manage between their agents without bringing the organization into chaos. This question about the speed of standardization is crucial for all managers throughout many industries, and we hope to bring some insights and strategies to enable better managerial decision-making.

Chaos and Network Theory, as well as non-linear dynamics offer new perspectives for the management of complexity in organizations and social structures (Mitchell, 2011). Increased interconnectivity in these systems deliver increased complexity and therefore new paradigms for management must be developed. Old command and control paradigms are no longer effective in an environment of constant "white waters" (Vaill, 1996).

Understanding organizational and social behavior is a fundamental issue when trying to increase the value creating capability of societies and the well being of human kind. We take a network perspective in the organization and extract large datasets of the connection patterns between the stakeholders in order to understand the structural and functional characteristics of the organization. Specially in the last decade this has been possible due to technological advantages, as large datasets have been taken of biological, technological, and other scientific fields. Some scholars have attempted to cluster these datasets in a multidisciplinary approach to the study of complex systems called complex network analysis (Strogatz, 2001) (Newman, 2003b) (Boccaletti et al., 2006).

In this article, the vehicle for standardized information exchange is the Deming Circle PDCA (plan do check act).

In order for organizations to be successful vast amount of information must reach and be understood by all relevant stakeholders at ever increasing speed. Standards serve this purpose: create the necessary conditions for sustainable growth. This article presents the application of chaos theory and non-linear dynamical systems in the field of organizational and managerial theory and discuss about the effect of standardization speed in complex organizations.

We begin by describing what we understand as the network organizational paradigm. We then continue discussing the evolution, formation and dynamics of structural and functional connectivity in the organizational network. We then describe the implications of this dynamics and try to find a model that describes this behavior in the chaos theory. Finally we discuss some of the issues associated with this behavior in one field example and the possible extrapolation of the model for further research.

Progress will rest in taking at least three interdependent steps: (Kelso, 1995)

1. management theory must incorporate models of pattern formation and cooperative phenomena for analyzing the spatiotemporal dynamics of organizational networks.

2. technology is needed to measure and control this dynamic patterns with enough spatial and temporal resolution.
3. inspire a paradigm shift in Management towards identifying control parameters and collective variables for these dynamic patterns of organizational activity.

The first step is to describe a model of pattern formation for analyzing dynamics or the organizational network. Our model of organizational standardization dynamics explores the similarities of real organizational networks with neural brain networks and tries to explain the organizational network dynamics in the standardization process by building analogies between neuroscience and organizational theory. Further analysis is later extended to the level of a single agent. Supported by technology we will gather extensive datasets to analyze these patterns. In a third step, we will try to identify control parameters and collective variables for these dynamical patterns in order to find an optimal standardization sequence. There are several studies of management that have tried to describe an optimal project management approach through theory of chaos (Curlee and Gordon, 2010) (Saynisch, 2010) at different aggregation levels, but to the best of our knowledge there has not been yet a systemic approach that recommend an optimal standardization sequence. We try to fill this research gap. We try to fill the research gap with this paper.

As Box and Draper put it "all theoretical models are wrong, but some are useful" (Box and Draper, 1987). So we try to propose a model for standardization process in complex organizations that might be of use and provides some insights that can be translated into useful management strategies.

2. Formal Model of Organizational Standardization Dynamics

A network is a conceptual representation of a real-world complex structure and is given by a number of agents (vertices) and links (edges) between the agents. Let G be a finite graph, and let V=V(G) denote the set of vertices of G and A=A(G) the set of edges, then the graph is directed when A describes a pair of directed vertices u and v being connected u->v or v->u (Bang-Jensen and Gutin, 2000). In a simplistic representation of a physical network, for instance the brain, the agents would be the neurons and the links would be the axons connecting them. An organization, considered as a network, might be described as a number of agents (the people in the organization) and a number of links that connect them. For the purpose of the paper, we explain later why and what the nature of these links are, we consider these links to be directed, weighted, depending on how strong they connect the agents, and standardized, this means that they all have the same nature. Hence our organizational network has the structure of a directed weighted graph (van Steen, 2010).

A network structure describes the architecture of the network: what agents are connected to what others and how. The degree of a specific agent resembles the number of links connected to that agent. The degrees of all agents in the organizational network comprise the degree distribution, which is important to describe network evolution and resilience (Smith, P. et al., 2011).

An important information-oriented approach to organizational theory is given by Fujimoto (Fujimoto, 2001) who describes how information management is the key for proper management of the value creation process. In an organizational network, segregation and integration of information can be understood as competing feed-back loops (FBLs) (Senge, 1990). Functional segregation of an organization is the ability for specialized information processing to occur within interconnected groups of the organization. Functional segregation brings efficiency to the organizational network. Functional integration establishes relationships between different groups of the organizations and brings coherence of the overall behavior, hence leading to an increased effectiveness along the value stream. In fact, we argue in this article that the previous mentioned two FBLs act upon the behavior of the organizational network and deliver specific quantifiable characteristics that can help managers empower their organizations achieve increasing performance levels, hence helping society prosper and advance.

The problem of non-linear dynamics was first tackled by Pierre Francois Verhulst in 1844 and published in 1847 (Verhulst, 1847), at the age of 40, while trying to describe the growth model of a closed population (no immigration, no emigration) facing an environment with limited resources. This model was "re-discovered" in 1974 and published 1976 by Robert May (May, 1976), in part as a discrete-time demographic model. Today this method is used in different scientific researches such as technical science (Sotiropoulos, 2011), meteorology, economics (Ausloos and Dirickx, 2006) (Hamacher, 2012) (Banks, 1994).

The discrete version of Verhult´s equation has become extraordinarily useful and popular after the magnificent numerical analysis made by Mitchell Feigenbuam (Feigenbaum, 1978) Special attention was given by Feigenbaum to the qualitative change in behavior of the trajectories as the control parameter R is changed showing period-doubling bifurcations leading to chaos. The values of $R_m(n)$ that deliver the first bifurcation are important, because they show when the standardization process stops being homogeneous. Homogeneity refers in this case to reduced variability in the time spent in the standard. This concept of negative variability, MURA in japanese, is extensively studied by Masaaki Imai (Imai, 1986). In his argument is detailed why this variability brings a loss in performance in the continuous improvement process.

Mathematically, the multidimensional problem is written

$$\begin{bmatrix} x_{1n+1} \\ x_{2n+1} \\ \vdots \\ x_{m-1n+1} \\ x_{mn+1} \end{bmatrix} = \left(\begin{bmatrix} R_{1n} & 0 & 0 & 0 & 0 \\ 0 & R_{2n} & 0 & 0 & 0 \\ 0 & 0 & \ddots & 0 & 0 \\ 0 & 0 & 0 & R_{m-1n} & 0 \\ 0 & 0 & 0 & 0 & R_{mn} \end{bmatrix} \otimes f \begin{pmatrix} x_{1n} \\ x_{2n} \\ \vdots \\ x_{m-1n} \\ x_{mn} \end{pmatrix} \right)$$

Formula (1).

where m are the agents in the network and n represents the discrete time and $f: \mathbb{R} \to \mathbb{R}$ is a function with real arguments and values.

The classic interpretation (May, 1976) of this equation, is that the elements of the vector X_m(n) are numbers between zero and one that represent the ratio of existing population to the maximum possible population in the time unit n. R, classically considered constant, is a positive number representing a combined rate for reproduction and starvation. In a way can R be considered as the capacity of the system to carry a certain population. The quadratic logistic map with constant R, presents a very well studied behavior (Ausloos and Dirickx, 2006) with different types of bifurcations and chaotic behavior for different values of R and almost all initial conditions. The first bifurcation takes place for values of R close to 3.

In our model, X_m(n) are numbers between zero and one that represent the standardization ratio that an agent m is spending in a given time n using the standard PDSA for process management and the total amount of time that this agent has. The elements of the matrix R_m(n), represent in this model the number of PDSA links between the organizational network agents. R_m(n) can be understood as a connectivity degree. The elements of R_m(n) are not constant but are a function of time n and of the agent m. This makes the system a non autonomous discrete dynamical system (Shi, 2012). This means that the number of links, standardized by PDSA, that any agent can have in the network can evolve with time. The PDSA build up a standardized connection between the network agents. The hypothesis is that the more process owners train the PDSA, the more efficient the organization will become just as the more myelinization happens in a brain, through repetition and practice, the more efficient the organism becomes realizing a certain task (Gazzaniga, 2000)

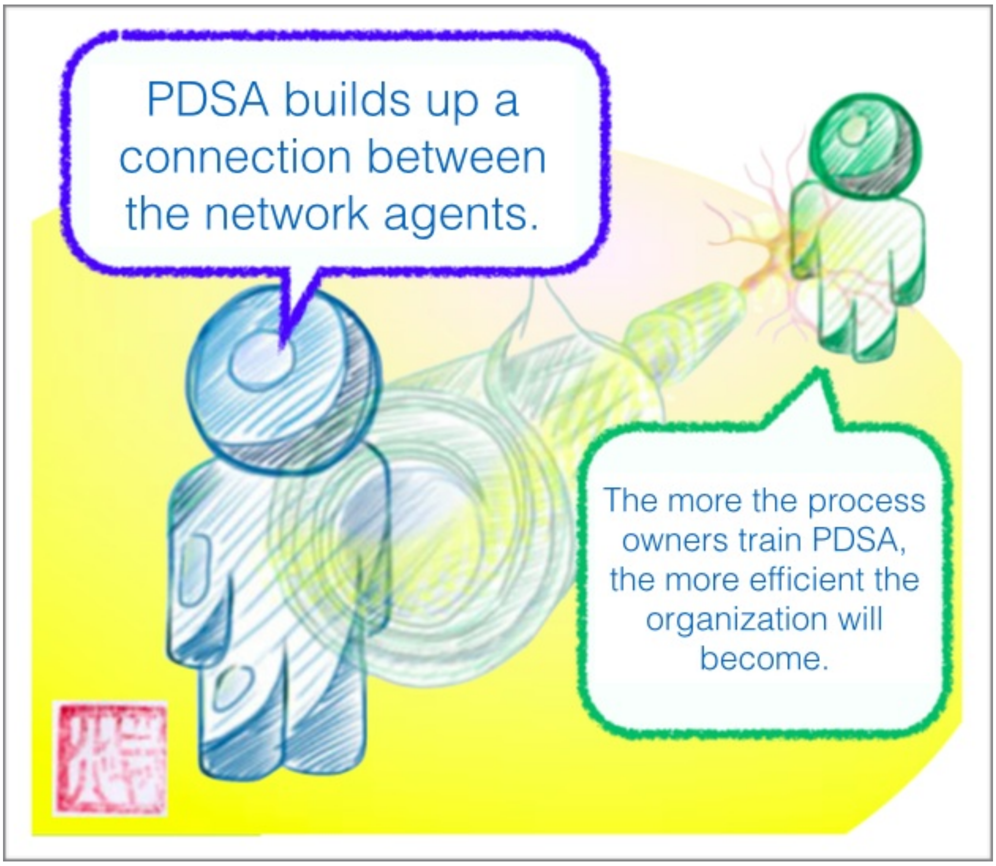


Figure 8. "Myelinization" of the organization through PDSA. (Villalba-Diez, 2013a)

In essence, our hypothesis is that (1) describes the learning effect that happens at an agent level, that states that the ratio of time spent in a given moment in time depends on the state spent on this standard in the past. Chaos and stability on non autonomous discrete dynamical systems has been studied (Aulbach and Rasmussen, 2005) (Elaydi and Sacker, 2005) and their complexity attracted lots of attention (Franke and Selgrade, 2003) (Zhou and Zou, 2003). An autonomous discrete system is governed by a single map, but the non autonomous discrete system is governed by a sequence of maps that may have different dimensions. Kolyada and others (Kolyada et. al,

1996) introduced the concept of topological entropy for non autonomous discrete systems and studied its properties.

Due to the powerful theorem by Metropolis we know that the order in which stable periodic solutions appear is independent of the unimodal map being iterated. That is, the periodic attractors always occur in the same sequence. This is called the universal or U-sequence (Metropolis and Stein, 1973).

We aim to find the fittest $f(X_m(n))$ in (1) to best describe the organizational network dynamics in the standardization process governed by two concurring FBLs. We postulate at an agent level a positive FBL of functional integration that activates the network, and a negative FBL that resembles the segregation effect in the organizational network that hinders further propagation of the standard. As the time spent by the network agents on PDSA increases, the negative FBL becomes larger, and a steady FBL shifting dominance appears. This concept was first introduced by Forrester in (Forrester, 1961) and (Forrester, 1969).

System Dynamics is an approach to understanding the behavior of complex systems over time by dealing with internal FBLs that affect the behavior of the entire system. Unifying the idea of FBLs of different polarities and the switching dominance between them is a central thought of system dynamics that has been applied to economics, ecology, organizations, as for instance stated in (Sterman, 2000). This concept has been taken to management theory by Peter M. Senge in (Senge, 1990). Senge argues that the building blocks of complex systems are FBLs, and that only with a maximum of three FBLs, any system can be explained and managed.

The behavior of this dynamical system is dictated by the shift in power of two conflicting FBLs:

The positive FBL activates the network, and while the connectivity degree $R_m(n)$ of the network remains small, the time spent by the network agents using the standardized linkage increases almost exponentially. The negative FBL that resembles the saturation of the network remains of second order because the network capacity is not reached yet. As the time spent by the network agents on the standardized linkage increases, the negative FBL becomes larger, and a steady FBL shifting dominance appears. In this case, as R_m(n) increases, the network becomes saturated and the positive FBL becomes weaker with respect to the more active negative FBL. At equilibrium, both loops are equally active, and in balance.

Therefore we propose, for any agent following model for behavior

$$\begin{bmatrix} x_{1n+1} \\ x_{2n+1} \\ \vdots \\ x_{m-1n+1} \\ x_{mn+1} \end{bmatrix} = \left(\begin{bmatrix} R_{1n} & 0 & 0 & 0 & 0 \\ 0 & R_{2n} & 0 & 0 & 0 \\ 0 & 0 & \ddots & 0 & 0 \\ 0 & 0 & 0 & R_{m-1n} & 0 \\ 0 & 0 & 0 & 0 & R_{mn} \end{bmatrix} \otimes \begin{bmatrix} x_{1n} \cdot (1 - x_{1n}) \\ x_{2n} \cdot (1 - x_{2n}) \\ \vdots \\ x_{m-1n} \cdot (1 - x_{m-1n}) \\ x_{mn} \cdot (1 - x_{mn}) \end{bmatrix} \right)$$

Formula (2)

The non-linear difference equation at an agent level represented in (2) is intended to capture two effects:

- integration where the time spent by the agent using the standard increases at a rate proportional to the current time spent.
- segregation where the growth rate decreases at a rate proportional to the quadratic form of the time spent using the standard by the agent.

R_m(n) changes with the discrete time and can be different to different agents. As the research by Kuroiwa and Miki (Kuroiwa and Miki, 2004) show, the period-doubling route to chaos is observed in different time-dependent values of R_m(n). It is also important to remark, that this time-dependent evolutional approach to an organizational network has again a parallel in brain research as Aihara and Matsumoto show (Aihara and Matsumoto, 1986). This gives a hint of the importance of this matter in other research fields such as biology and neuroscience. The network is not random as it is constrained into a hierarchical structure of the organization. This two facts, hierarchical structure and the modularity created by the standardization of the linkages will maybe bring a hierarchical modularity to our organizational network that resembles many brain-like networks and properties (Sporns, 2010).

We propose following method for proving this hypothesis:

1. We will begin by gathering empirical data from the organizational subjects. Subjects will report xn, the time they spend using PDSA, and $R_m(n)$, the number of PDSAs they use at any given point in the discrete time.
2. We will analyze the data. For this, we will calculate the induced values of $R'_m(n)$ for two purposes: first make sure that the data are not faked by the population, and second in order to compare the reported, empirical $R_m(n)$ and the induced $R'_m(n)=x_m(n+1)/(x_m(n)*(1-x_m(n)))$ based on the reported values of agent m $x_m(n+1)$ and $x_m(n)$. The hypothesis is that if the system is described by a logistic equation similar to (2), then $R_m(n)$ should be very similar to $R'_m(n)$. The comparison of $R_m(n)$ and $R'_m(n)$ will be made using the Nash-Sutcliffe efficiency coefficient (Nash and Sutcliffe, 1970). Although this Nash-Sutcliffe model was developed to quantitatively describe the accuracy of hydraulic models, it can be used to describe predictive accuracy of other models as reported in scientific literature (Moriasi et. al, 2007). Nash-Sutcliffe efficiency coefficient can range from $-\infty$ to 1. An efficiency of $E=1$ corresponds to a perfect match between the model and the empiric data. An efficiency of 0, $E=0$, means that the model predictions are as good as the mean of observed empirical data. If $E<0$ it means that the observed mean is better prediction as the model. The Nash-Sutcliffe efficiency coefficient for an agent m compares the residual variance (in the numerator) and the

data variance (described in the denominator) of the formula below. Where R_m(n) represent the empirical data, R´_m(n) represent the induced model and represent $\bar{R}_{mn}$ the mean value of the empirical values. This coefficient can also be calculated for the whole organization, as we will show in the case study.

$$E_m = 1 - \frac{\sum_{i=1}^{n} (R_{mn} - R'_{mn})^2}{\sum_{i=1}^{n} (R_{mn} - \bar{R}_{mn})^2}$$

Formula (3)

3. Following this logic, we will take first a lagrangian approach to the system and will observe the behavior of the organizational agents. After this, we will take an eulerian approach to the organizational network and will study the behavior of the whole system.
4. To finish the analysis, we try to draw some conclusions based on the results obtained.

We now show an implementation of this model in a field research case study.

3. Case Study

The organization studied presents following structure with 33 agent to agent report. The agents, that are constrained in a hierarchical classical report organization. The organization has 1000 people, but we only analyze the managerial structure. The network is hierarchical, just as many organizations. This graph is directed, so that each agent reports to her upper level in a standardized process management form called PDSA as previously described. One PDSA manages one KPI and is owned by one process owner that reports it to the upper level as described.

We observe the 33 agent to agent relationships that form the organizational network in terms of how much time is reported to be spent by every agent using PDSA for a period of 30 weeks. As already mentioned, the network´s agents are free to decide what KPIs they use to report their processes, and are free to change those KPIs, always in agreement with their superiors in rank. For instance, a manager in production can have a problem with quality and report a KPI about quality for a certain period. Once this problem is resolved and the process under control, then the focus might change to cost reduction, hence changing the KPI and the focus of managerial actions. This fact is important, because it can lead to a hidden Markov´s chain (Norris, 1998).All organizational network agents communicate with the same pattern (PDSA), as this links are standardized at all hierarchical levels in the organization, as a result, the structure of the network presents a high modularity.

Summing up: we study a directed organizational network with 33 agents that presents a high modularity, weighted nodes and weighted linkages. We want to find out the non-linear dynamics of the organizational network and try to test a model that describes the best conditions for fast and sustainable standardization.

We start by collecting the data. As already mentioned, the network has 33 standardized PDSA links between different agents. Throughout a period of 30 weeks, the agents reported $x_m(n)$, the time they spent using PDSA, and R, the number of PDSAs they were currently using. The agents were not informed about the hypothesis of logistic behavior. This is important to avoid not wanted effects such as those described by Goodhart (Goodhart, 1981).

After collecting the data of $x_m(n)$ and $R_m(n)$, we study the behavior of $x_m(n)$ for all agents through different times. The discrete time n unit is the week. Here an example for a node in the network and her reports: we observe easily identifiable and similar behavior in all nodes such as strong beginning and oscillations towards the end of the period.

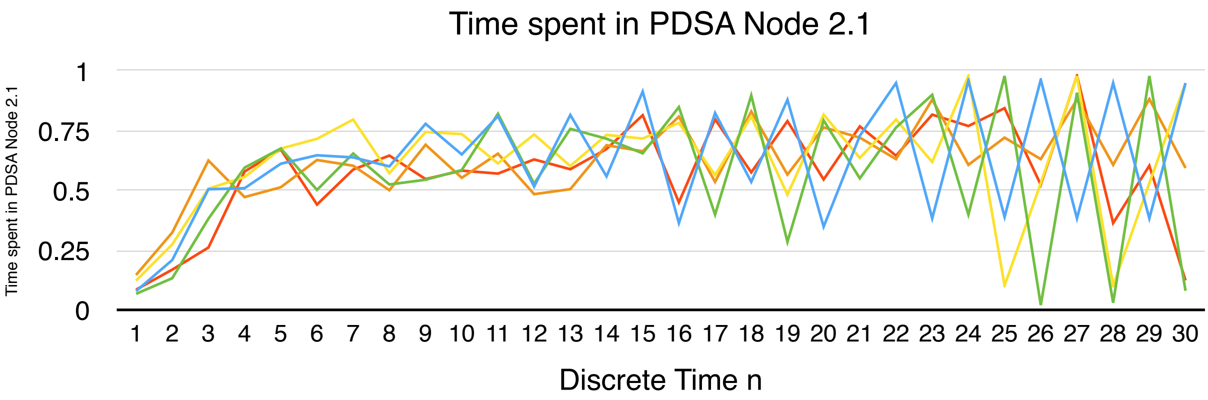


Figure 9. Time spent in PDSA by one Node

For the same node, we show the plausibility check for the values of R_m(n) and we see that we obtain real values. We also observe values of R between 2 and 4 in the first 20 periods, and a very high oscillating behavior after the 20th period. This behavior repeats in all othernodes.

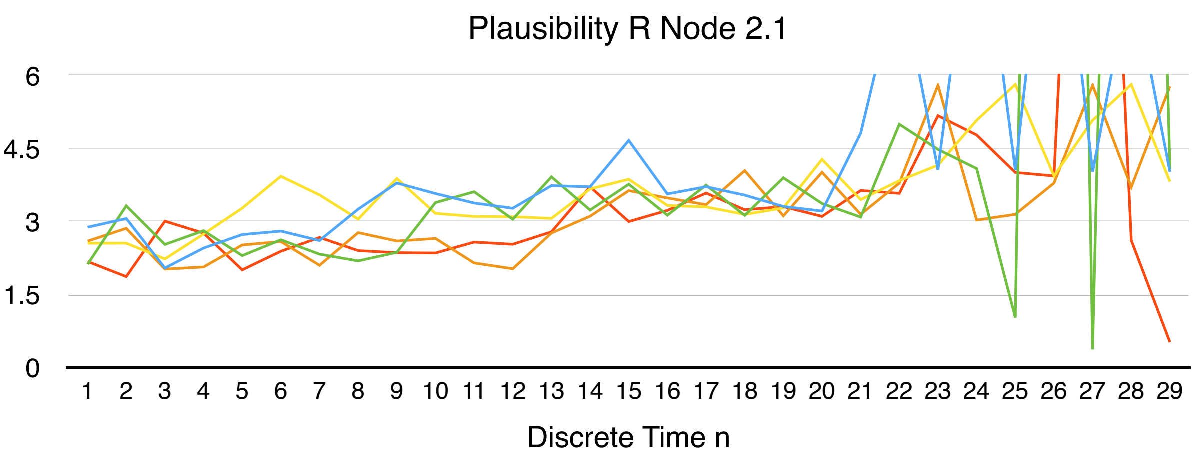


Figure 10. Plausibility of R for one Node

We represent first the time consumed in using PDSA of the whole system and the factor R_m(n).

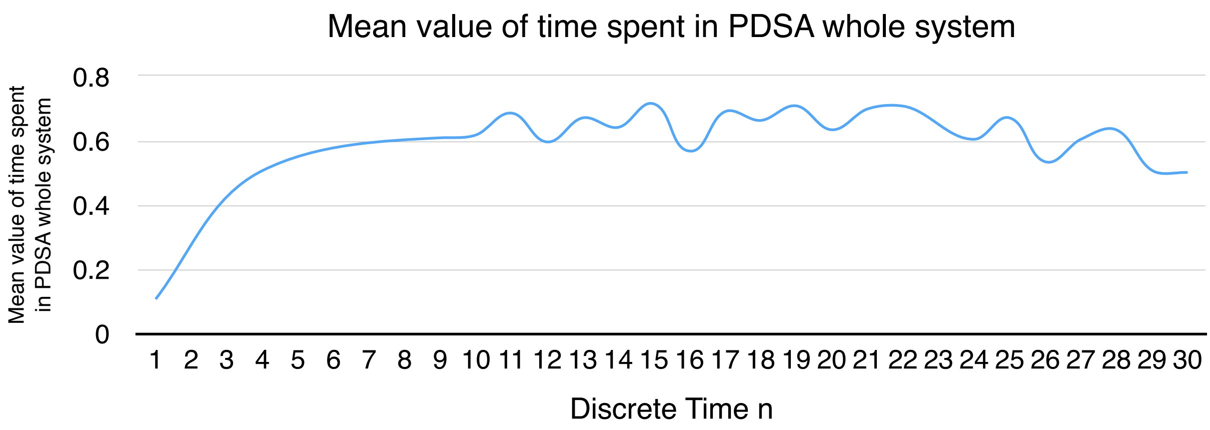


Figure 11. Mean value of time spent in PDSA whole system

The whole organizational network is much more stable than at the agent level. We see this in the mean value of time spent on PDSAs. The oscillations found at the agent level are not found for the whole organizational network. This means that although there might be local instabilities, the system as a whole is far from bifurcation. In other words, local instabilities might lie hidden behind aggregated behavior.

Now, for the whole organization, we represent the empirical (reported) values of R_m(n) and the induced values of R´_m(n)=(x_m(n+1))/(x_m(n)*(1-x_m(n))) assuming the organizational behavior would resemble a logistic equation. We observe that the induced and the empirical values behave similarly as long as R_m(n)<3. When R_m(n)>3, the organizational network stops behaving as described by the logistic equation would foresee. We see this in the oscillations of the induced values of R_m(n). This is consistent with Kuroiwa and Miki´s insights about the bifurcation of non autonomous discrete systems who affirm that the first bifurcation will happen with values of 3<R_m(n)<4. This means that in order to achieve a predictable standardization of PDSA, the number of PDSA links, and hence the number of KPIs between the agents lie between 3 and 4. This is an important insight supported by the analysis that gives managers a guide on how many KPIs should be given to each report in the organization in order not to drive the organization into chaos.

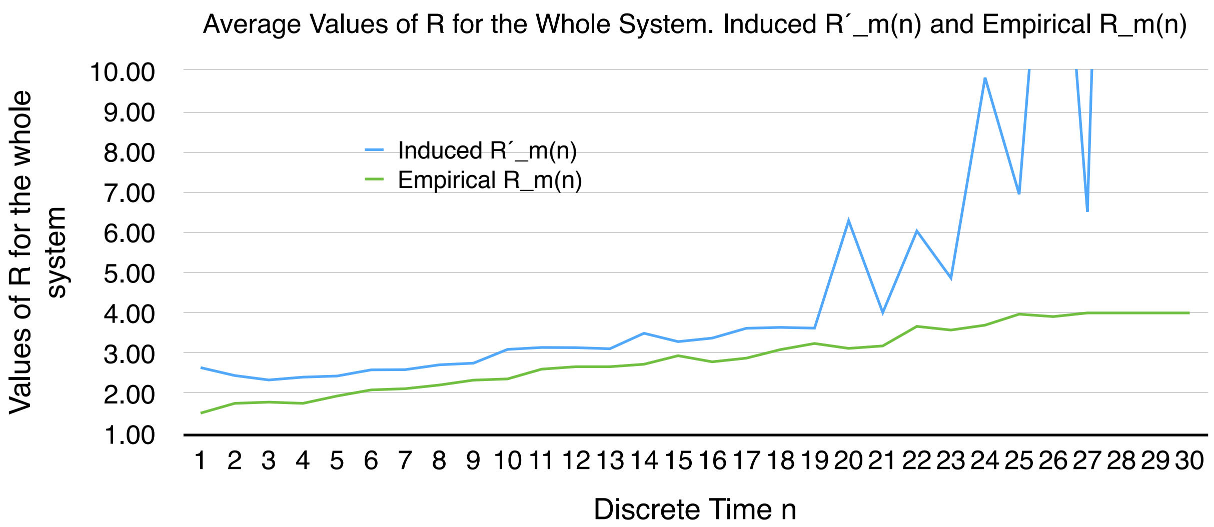


Figure 12. Average Values of R for the Whole System. Induced R´_m(n) and Empirical R_m(n)

Now let´s analyze the Nash-Sutcliffe efficiency coefficient for both each agents and the whole system and will try to see if this helps us verify some of these insights and quantify the degree of accuracy of the proposed model. Taking into consideration the previous figure, we foresee a phase change for R around 3, therefore we represent the Nash-Sutcliffe coefficient before and after this value is reached.

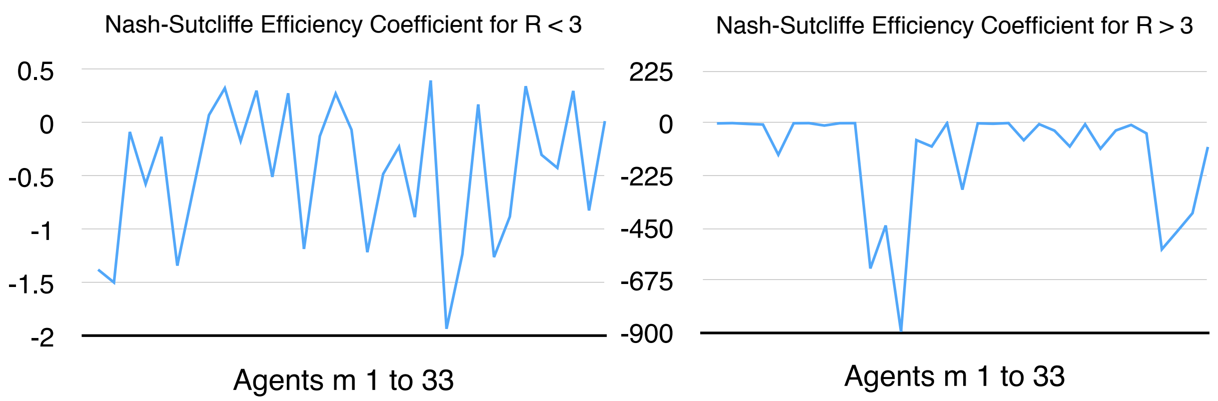


Figure 13. Nash-Sutcliffe Efficiency Coefficient for the different agents

We observe, that the values of the Nash-Sutcliffe coefficient are almost always below zero, for most of the discrete time, therefore we conclude that at an agent level, the model does not describe homogeneously, a clear logistic behavior.

Now we calculate the Nash-Sutcliffe efficiency coefficient (E) for $n<21$ ($R_m(n)$ smaller than 3) and for $n>20$ ($R_m(n)$ bigger than 3) for the whole organizational network.

$E=-0.898$ for $n<21$ ($R_m(n)$ smaller or equal to 3).
$E=-523.3$ for $n>20$ ($R_m(n)$ bigger than 3).

This means that the efficiency of the non autonomous discrete dynamical logistic model describes very accurately the behavior of the system as long as the average number of PDSAs that link the agents are smaller or equal to 3. For values of $R_m(n)$ bigger than 3, we observe a radical change in this efficiency, and our logistic model is not able to describe reality as such, and so the mean value of empirical $R_m(n)$ is a better predictor as our model.

This result lets us suggest that the non autonomous discrete dynamical logistic model can predict the holistic, eulerian, behavior of the standardization dynamics as long as the average number of PDSA links between the agents remain smaller or equal to 3. With $R_m(n)$ bigger than 3, the standardization dynamics are not predictable with the logistic model.

We will use this, in my opinion, important conclusion in our later discussion about Hoshin Kanri.

To finish the analysis, we represent the phase diagram $x_m(n)$ to $x_m(n+1)$ of mean values of all agents in the organization and observe that there is an attractor for values of $x_m(n)$ around 0,65. This is again an important insight, because it means that if the system were to follow a pure logistic model, it would have a stable fixed point in the standardization´s rate of around 65% of PDSA utilization.

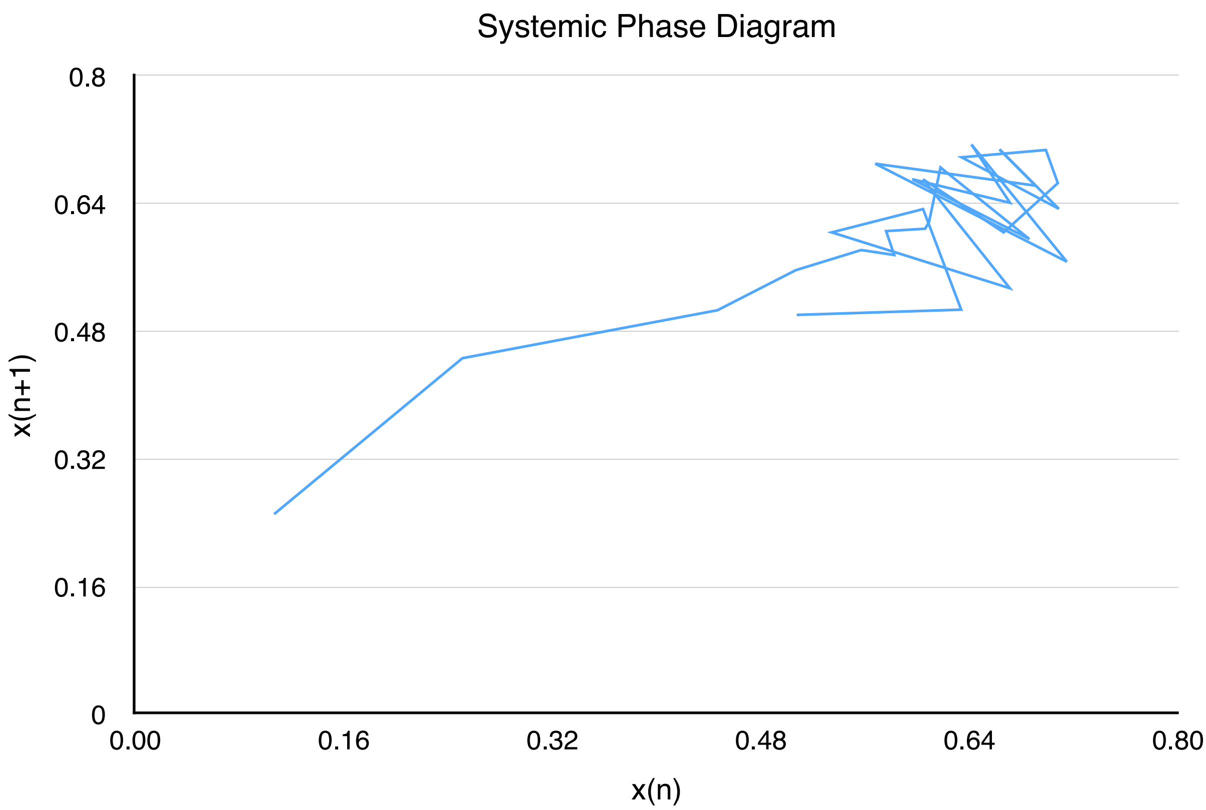


Figure 14. Systemic Phase Diagram for Whole System

Saynisch (Saynisch, 2010) uses a phase-oriented approach to project management based on a sequence of evolution-equilibrium alternance. We use here a similar idea, but applied to the standardization process and the empirical equilibrium point of standardization rate of 65%. From this interesting fact, we suggest a possible standardization sequence that includes several phases. And would be this: not try to "comb" the whole organizational network with a standard at the same time, but first reach around 65% of the team members, let this result stabilize and then approach 65% of the 35% left in a second phase, attaining a standardization rate of around 87% of the population. A third phase would then attain 95% of the team members and so on. The next picture visualizes this approach.

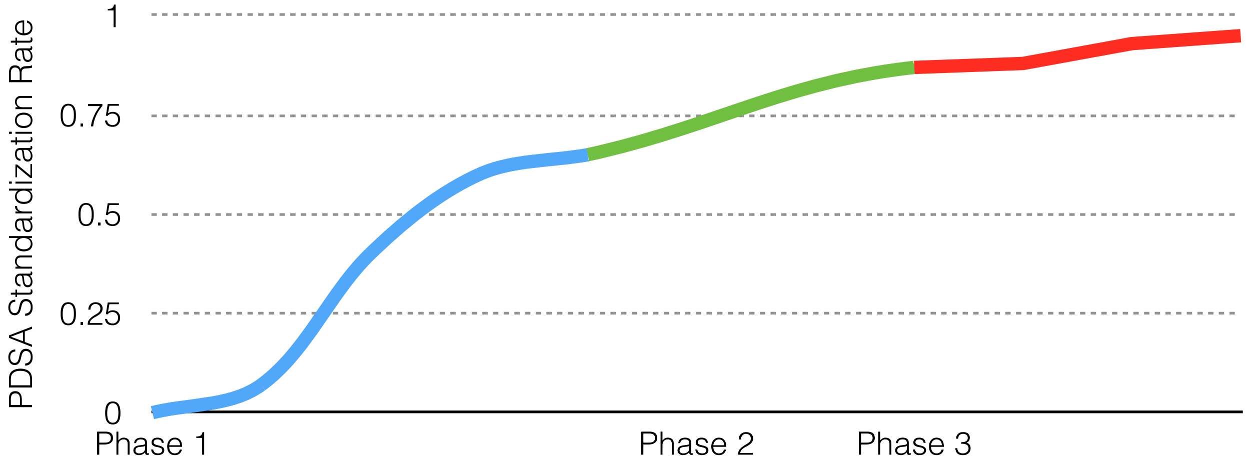


Figure 15. Standardization strategies in different phases

C. Performance Management

As previously stated, a process is a sequence of interdependent steps which at any stage consume resources to transform an input into an output. This output serves as input for further processing and is a constraint for the input as well. This output is of value for a certain customer, hence a process can be understood as a value stream.

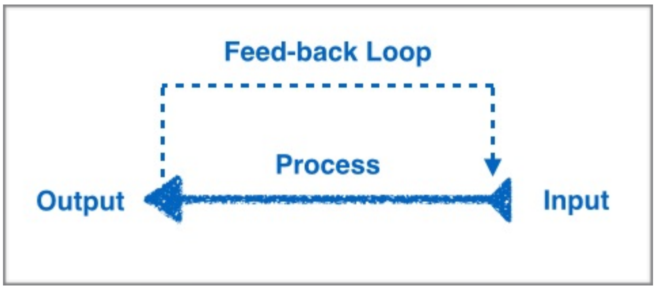


Figure 16. Process Paradigma.

Another way to look at the self-evident fact of the inherent interdependence of a process is its feed-back loop based nature. In the example from above, there is a driving force, the value creation that transforms an input into an output, and there is a constraining force that allocates resources and regulates growth.

Using this definition of a process, we can cluster performance measurement indicators into

- input KPIs
- process KPIs
- feed-back loop KPIs
- and output KPIs.

I understand this process view to be self evident, and to the best of my knowledge, has not been stated in such a way before. Other authors have other approaches. For instance, Peter Babin in (Babin, 2007) differentiates between performance measures, if they measure performance and deliverables, if they measure the timely accuracy of execution. Elizabeth Cudney in (Cudney, 2009) focus on the opportunities for improvement along the value stream without specifying further detail. Stephen Bonham (Bonham, 2008) places the dichotomy between metrics fed by processes, by projects or by risks. David Hutchins (Hutchins, 2008) prioritize KPIs with a bi-dimensional matrix depending on the degree of difficulty to improve the KPI and the KPI impact on vision or strategy. Robert Kaplan and David Norton in (Kaplan and Norton, 1993) set up the backbone of the balanced scorecard upon four perspectives: financial, customer, internal and innovation or learning perspective. I believe that my approach is more general, in part due to its simplicity, than any of the stated, and I will try to argue this in the next paragraph.

Any team member of an organization is a process owner of at least one process - notice that if a team member does not own a process in an organization, then management is not using its assets properly, and this issue will be also revealed through KPIs - Being this the case, and assuming that team-members in their role of process owners will seek to better their processes locally in their own interest, I am of the strong conviction that the backbone of any organization is the process structure, because it lies in the interest of every single team member to thrive in the process they own. Then, if, throughout the KPI structure we understand the process structure and the organizational topology - remember that the KPIs connect the process owners through the PDCAs - we will be able to empower the process-owners find, for their specific needs, optimally suited organizational topologies, we will be able to empower the process-owners attain better process performance while empowering their teams to learn in the sense of a "learning organization" (Senge, 1990).

Charles Goodhart, a former advisor to the Bank of England and Emeritus Professor at the London School of economics, puts it like this "As soon as the government attempts to regulate any particular set of financial assets, these become unreliable as indicators of economic trends" (Goodhart, 1981). This, so he argued, happens because investors anticipate the consequences of the regulation in order to benefit from it. While this idea is originated in the context of macro economics, Goodhart´s Law has profound implications in the selection of performance indicators in organizations (Chrystal and Mizen, 2001) (Danielsson, 2002). In broader terms stated, Goodhart suggested that "any observed statistical regularity will tend to collapse once pressure is placed upon it for control purposes".

In the context of quantum physics, Heisenberg (Heisenberg, 1927) introduced a concept of invariance known as Heisenberg Uncertainty Principle that states that the observation of a system disturbs its behavior. In social science, extensive and intensive research have shown that the observation of social interaction not only changes the behavior of the subjects while being observed, but also changes their beliefs when they read the results of the studies. This phenomena is called reactivity (Heppner et al., 2008) and has many forms and names: Hawthome effect (McCarney et al., 2007) when subjects know they are being observed and change their behavior, Pygmalion or Rosenthal effect (Eden, 1992) depending if subjects change their behavior to perform better or worse depending on expectations.

Issing and Wieland (Issing and Wieland, 2001) have reflected on these issues and formulate the question that if Goodhart´s law would be generally valid, policy makers would be facing an impossible task in breaking this vicious circle. The question lies open if Goodhart´s law makes any effort of measuring performance for process regulation an insurmountable task. If it is not possible to rely in statistical regularity for control purposes, in what then?. Issing and Wieland point out that the solution lies in the choice of instruments and methods for measurement and targets. Another idea would be to collect ALL of possible KPI in such a way that not-fully pressure can be carried out over opposite directions or the effect will be neglectable.

The fundamental flaw in a number of policies and management concepts is given by Goodhart´s important insight. Classical KPI Management research (Kaplan, 1992) (Parmenter, 2010) (Spitzer, 2007) (Kaplan, 2004) follow the path of identifying few independent KPIs that serve as a "balanced scorecard" of an organization or process in the assumption that measuring these indicators will give an image of the whole when"deploying" (Fayad and Rubrich, 2009) them down the hierarchy.

I suggest a different approach based on the interdependent nature of processes. I suggest that not only is performance to be measured by relying on the statistical regularity of a certain set of KPIs, but because processes are interdependent, we need to understand how KPIs influence each other in order to best rearrange the KPI Managerial System.

In the next paragraphs, I will first give an overview of the main process and output key performance indicators used for measuring performance in organizations. After giving this overview, I will seek a reasoned qualitative organizational "connectome" (Sporns et. al, 2005) or correlation between process and output KPIs taking this way into consideration state-of-the-art scholar research methods in neurobiology in order to better grasp the qualitative nature of our KPI ecosystem.

1. Overview of most relevant KPIs.

We start our analysis by giving a not closed list of important KPIs used in a wide variety of industries and processes.

1. Takt-time, from the german "taktzeit" is defined as the time in which a process performs one given task (REFA Verband, 1985).
2. Overall Equipment Effectiveness (OEE) relates the performance of a process through three independent measures: availability, performance and quality (Hansen, 2001).

3. Work in Progress or Work in Process (WIP) resembles the amount of work that has entered a process and has not been finished yet.
4. First pass yield (FPY) is defined as the percentage of units coming out of a process without re-work. Gives a quantitative measurement on the quality of the process.
5. Hours per Unit (HPU) is defined as the number of team-member hours is dedicated to process one good unit throughout the process.
6. Defect Parts per Million (DPPM) is a KPI used in quality management to measure process quality. Can be defined as the average number of defects in an average production run multiplied by one million.
7. Mean Time Between Failures (MTBF) is the predicted elapsed time between inherent failures of a system during operation (Jones, 2006)
8. Mean Time to Repair (MTTR) represents the average time required to repair a non-functioning process.
9. Throughput (TH)represents the rate of processed units per time.
10. Lead time (LT) can be understood as the latency between the initiation and the execution of a process. Given Little´s Law (Hopp and Spearman, 2011) lead time can also be understood as the time needed to cover customer demand with the available WIP.
11. On-Time Delivery (OTD) is standard KPI measurement to measure the fulfillment of a customers demand to the wish date.
12. Inventory Turnover is the number of times that WIP is depleted.
13. Direct Material Cost (DMC) is the amount of money invested in the processing of a product.
14. Every Part Every Interval (EPEI) represents the frequency in which a set of SKUs go through a process within a repeated schedule. Resembles the flexibility of a process.
15. Average Number of PDCAs per Team Member represents the average number of PDCAs that own per Team Member in the organization.

16. Training Hours/Team-Member/Year is the average time that a team member spends per year in training activities.
17. Labour Turn Over is the rate at which an employer loses employees.
18. Team Member Absenteeism rate is the rate of employees failing to report to work when they were scheduled to do so.
19. Team Member Sick rate is the rate of employees that are sick and therefore not working.
20. Average Duration of Employment is the average time that a team member stays in the organization.
21. Frequency of communication of Corporation Goals to all Levels gives how often the organizational goals are communicated to all team members.
22. Number of hierarchical levels in the Organization represents the number of structural report levels in the organization.
23. Working Days Lost (WDL) represent the working days lost due to work-related illness and workplace injury.
24. Return on Sales (ROS) is the ratio of operation income divided by the net sales.
25. Return on Investment (ROI) is a way of considering net profits in relation to capital invested.
26. Return on Capital Employed (ROCE) is an accounting ratio used in finance that correlates the EBIT (earnings before interest and tax) and the net assets or capital employed.
27. Wrong deliveries rate is the rate of wrong deliveries that a process has to it´s customers.
28. Image is the mental image that stakeholders have when the firm is mentioned. It is a psychological impression and changes over time (Balmer, 2001).
29. Rate of unanswered calls is the rate of not answered requests for information to a process-owner
30. Loss of Corporation´s Secrets represents the number of corporate secret´s that are stolen from the company´s know-how base per year (Robinson, 2007)
31. Number of Patents is the number of patents that are approved per time-period.

32. R&D Investment rate the profit rate that is implemented into R&D.
33. Supply Chain Response Time is the response time to customer from a certain process from incoming order to delivery.
34. Number of Product Variants is the number of variants that a certain product presents.
35. Operational Profit pro Team member is the operational profit that is achieved per team member in a given time frame (usually a year).
36. Cash Flow (CF) is the move of money in and out of the business and it is usually measured in a period of time.
37. Cost/Unit the cost to produce a unit.
38. Sales Volume represents the amount of cash generated with sales per time period.
39. Market Volume in % market share in percentage.
40. Number of Customers number of customers.
41. Savings pro Team member cost savings pro team member.

2. KPI Correlation Matrix. Organizational Connectome.

Imagine we have the complete connectivity map, the connectome (Sporns, 2012), of two organizations. How would we compare these two connectomes agents each other? How much alike would these two organizations be, and how would we measure similarity? Now imagine that these structural patters change over time. If we could map an organization´s connectivity patterns each hour, week or year - how much would the network structure would have changed? What impact would these changes have on the organization´s value-stream performance? These questions are important because our aim in organizational management theory is to quantify processes in order to increase their performance.

Understanding the importance of KPI connectivity for organizational functioning has been recognized for a very long time (Kaplan, 1992). There has been several approaches to identify relationships between KPIs (Rodriguez et. al, 2010) however they focus mostly on the techniques for identifying the KPI relationships. With the goal in mind of empowering process owners develop further their capabilities, the next logical step after describing the most relevant KPIs of an organization, is to understand how they qualitatively influence each other.

The emphasis on KPI structure has a strong motivation: structure shapes function as well as function shapes structure. This seems to collide with Louis Sullivan´s premonitory quote "form follows function" (Sullivan, 1896). On the surface, both previous sentences seem to build an oxymoron, but nothing more far from the evolutional truth that states that functional outcomes are subject to selection pressures, which, in turn, has consequences for structural alterations (Darwin, 1849). Sullivan´s disciple Wright (Wright, 2005) stated premonitorily that "form and function should be one joined in spiritual union". We will use the KPI connectome as a building block for a more organic and integrative understanding of organizational functions. The premise is that the relationships between KPIs can be objectively verified and hence captures structural patterns. The KPI connectome puts also a big constraint on management theories because they need then be consistent with them.

Embracing the KPI connectome as a research method implies a shift toward a connectivity-or network based model of the organization. If we visualize then the KPI ecosystem as a network, with this correlation, we can identify what KPIs have a strong influence in the network. This is important, because KPIs of strong influence will have a more powerful impact in performance of the overall system, and it is necessary therefore to understand their weight in the KPI ecosystem.

The connectome matrix is color coded, for better visualization purposes, and can be interpreted like this: the KPI of each line influences strongly (dark green), slightly (green) or nothing (light green) the KPI in the column. The first thing we notice is that the matrix is sparse (George et al., 2011), with most KPIs not influencing or being influenced by the rest. This fact denotes the relative sparsity of large-scale interregional connections.

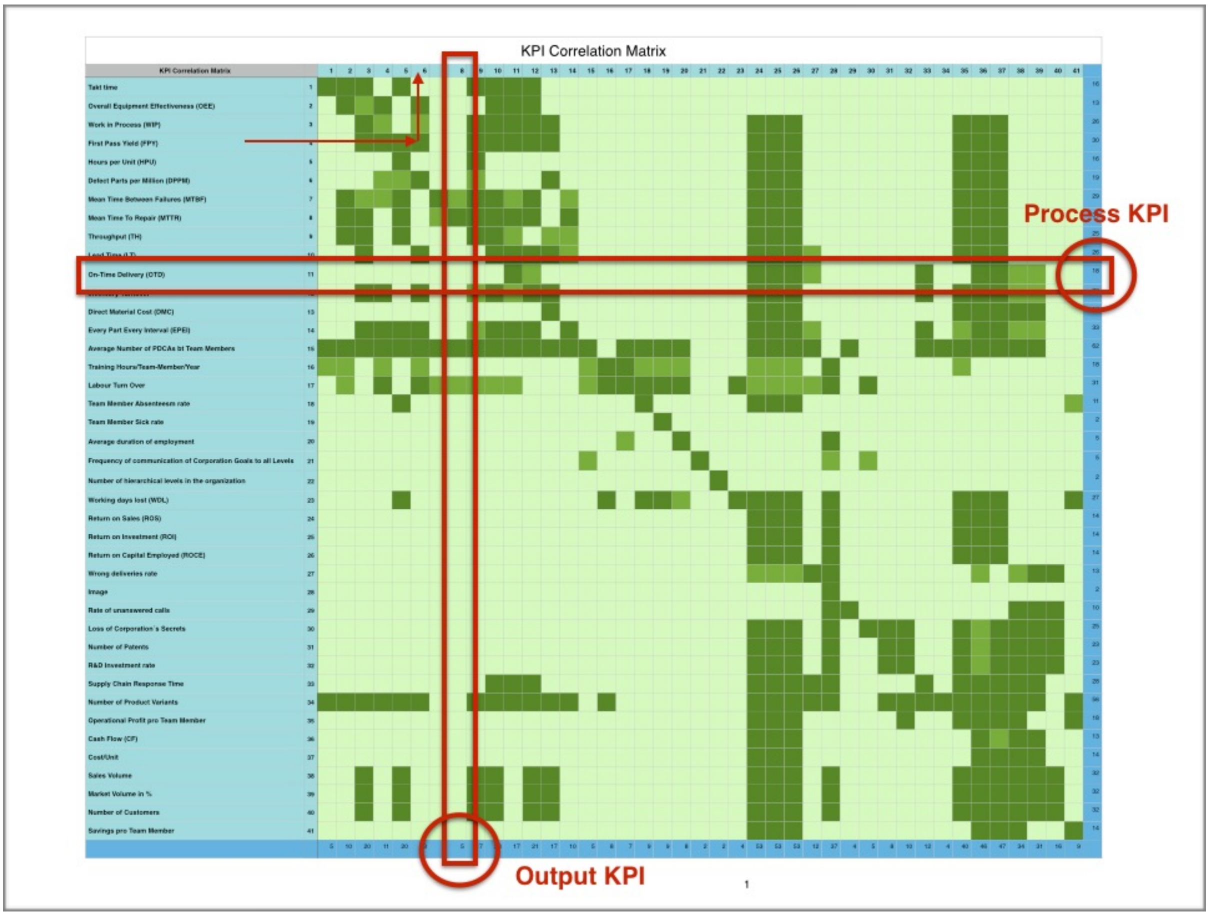


Figure 17. KPI Connectome.

We see in the example below for instance how the KPI Nr 4 (FPY) influences strongly (dark green) KPI Nr 6 (DPPM). If we quantify this strong, slight or absence of influence, we can then sum up the values of both lines and columns for each KPI.

The sum of a line, will tell us how strongly this KPI influences the rest of the KPIs and hence will give a quantifiable value of how strong this KPI is considered as a process KPI. The sum of a column for a given KPI will tell us how strong is this specific KPI influenced by the rest of the KPIs and hence give a quantifiable value of how strong is this KPI as an output or reporting KPI in the organization. This is important in order to understand how many relevant process and output or reporting KPIs our organization is using, and identify possible imbalances that may lead to problems such as those described by Goodhart.

In our first qualitative approach, the most important process KPIs are the average number of PDSAs that link each agent in the network and the number of variants of each product. The most important output KPIs in this KPI connectome are the ROS, ROI and ROCE. In the next picture we visualize this concepts with pareto logic.

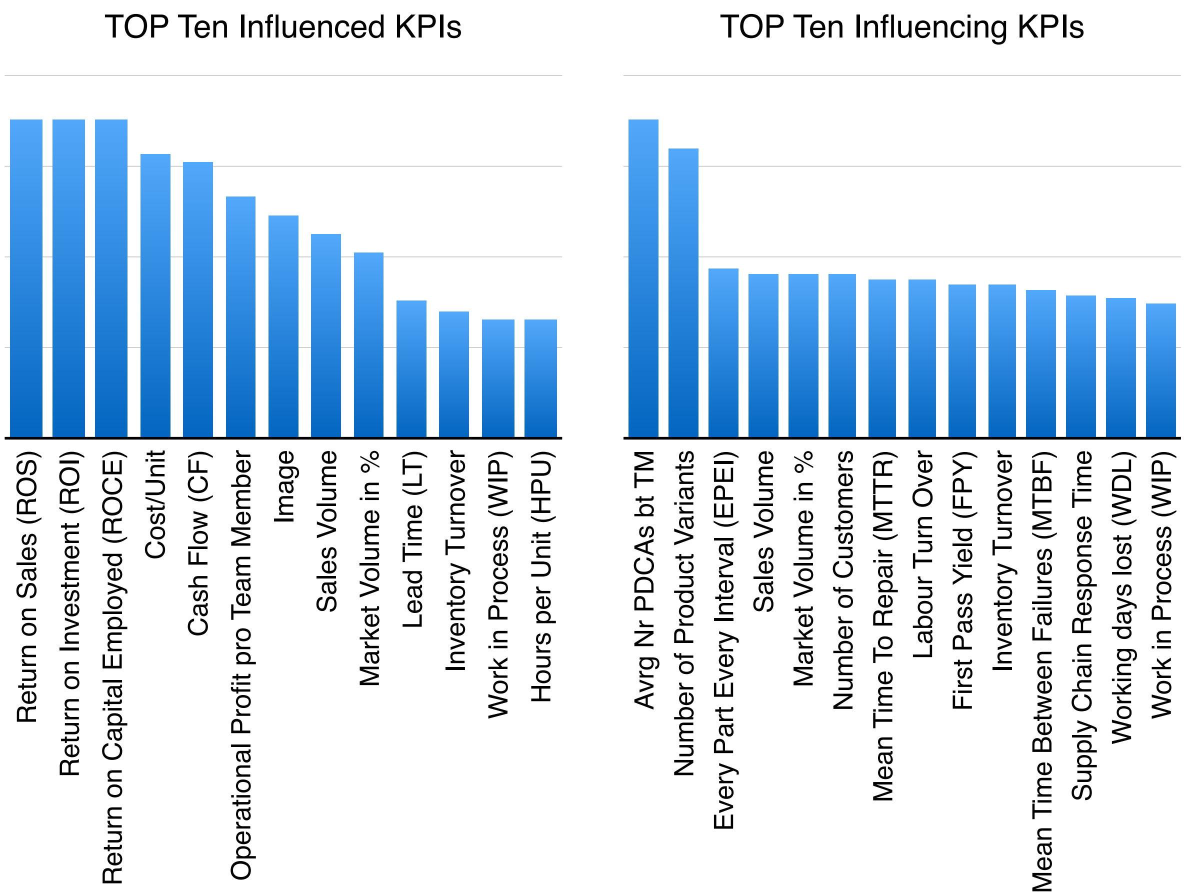


Figure 18. Pareto Analysis on Influenced and Influencing KPIs

In the next picture, we can also identify in the KPI connectome sub-groups with strong hierarchical clustering. The term "hierarchy" is used in graph theory and network analysis in the context of modularity and how much "hierarchiness" a network has can also be quantified (Corominas-Murtra et. al, 2010). Modules are used here generally in the sense of modules nested within modules. The idea that hierarchy is a critical design feature for evolvability of systems and organizations was given by Herbert Simon´s seminal research in the 1960´s (Simon, 1962). This concept of topological modularity states that network agents that are part of the same module have many intra-modular connections and few inter-modular connections (Newman, 2006). Meunier and his colleagues have verified Simon´s hypothesis for complex brain networks that systems organized in hierarchical modules can be fractally subdivided into ever smaller and denser modules and that this hierarchical modularity has important implications for the time dependent structure of brain dynamics (Meunier et. al, 2009). The resulting partitions might reveal important KPI network community structures. We will take this concept further in our Hoshin Kanri research for organizational complex networks. For now we can observe the picture below and notice the hierarchical clustering at least qualitatively.

Figure 19. Qualitative Clustering Visualization. KPI Connectome.

The purpose hence of analyzing the quantitative and qualitative KPI structure of an organization is more than the accumulation of large empirical data. The real promise derives from providing a mechanistic basis and a theoretical foundation for understanding the organization. The important step here to be given is the discovery of hidden regularities in the connection patterns that allow predictive reasoning in the organizational dynamics. An important idea is that the KPI structure is a complex network that shapes the function of an organization. It is important to map and analyze this network because its connection topology contains rich information about the history of both the organization and the individuals behaving in it. The structure of the KPI connectome preserves then a record of the organization´s past. This happens because connectivity is molded by the powerful forces of natural selection in evolution, and it is continually reshaped by development and experience.

This qualitative approach, based on expert knowledge, to the KPI structure of an organization is able to bring clarity into the KPI mesh, but could have the bias of the interests that each one of the experts would have, so Goodhart is still well and alive. The same flaw can be found in other approaches such as fuzzy cognitive maps (FCMs) described in the edited book about granular computing by (Papageorgiou and Stylios, 2008).

For further analysis, I will anyhow keep the network perspective among the organizational structure enabling us first, to gain some qualitative knowledge about the KPI ecosystem and second, to shift from a typically rigid hierarchical KPI organization described previously into eventually more flexible and resilient topologies (Smith, P. et al., 2011). I will discuss the effect of the euclidean topology of the organizational network in the next section.

D. Policy Deployment

Leadership theory, seeks alignment (Kaplan and Norton, 2006) (Covey, 2004) as supreme goal for the organization. But there is, to the best of my knowledge, not a single scholar that has quantified alignment so far. This quantification needs to be delivered and I try to fill this gap with my research.

The first reference (Kaplan and Norton, 2006), is mechanistic and in my opinion naive. It contemplates "cascading" from a dualistic "bottom-up" or "top-down" perspective, leaving no room for widely accepted theories such as Simon's "bounded rationality" (Simon, 1972) in which the agents of an organization make choices based on their interests or the social influences they are confined to.

The second reference (Covey, 2004) seeks a developmental approach from bottom-up, basing its emergent based alignment in the systemic empowerment of the workforce, that is based upon trust (Covey and Covey, 2008), being this based upon trustworthiness. We are going to embrace this second emergent approach and will integrate it with the previously mentioned complex networks perspective.

The study of complex networks has emerged as an important tool to deepen the understanding of many social, technological, biological and organizational real-world systems (Albert and Barábasi, 2002).

An important question regarding organizational management is the stability and reliability of relevant information transfer for the value creation, i.e., bring the necessary information to each stake-holder at the right time in the right quality is crucial for sustainable success (Fujimoto, 2001). This is a central concern of Hoshin Kanri: to determine what is the process in which valuable information is deployed throughout the organizational network. For this reason, Hoshin Kanri, has been mistakenly translated as Policy Deployment, hence giving the impression that Hoshin Kanri deals only with the deployment of information in one direction being this the top-down deployment of policies into the hierarchical topology. This relevant information is often called policy and the transmission of this important information across the organizational network is called deployment, hence policy deployment becomes crucial for sustainable organizational success.

The main approach for studying the stability and reliability of information transfer in complex networks is the percolation theory. That´s why percolation theory could be a vehicle to quantify and model hoshin kanri processes in real-world organizational networks.

The main question is: under what circumstances does the network topology become inefficient to transfer information in an efficient and effective manner? This can be measured by the percolation threshold.

The first attempts to explain social phenomena with percolation theory back to (Solomon et al., 2000) with the simplest case on a squared lattice-like network, and to (Moore and Newman, 2000) with a deep discussion about percolation on small-world networks. In (Arruda-Neto et al., 2002) we can find an application of percolation theory, based on a epidemiological model, to leadership and organizational management in which the speed for alignment is quantified under quite specific assumptions.

The idea presented by Arruda-Neto and colleagues is interesting, but limited if applied to a real world organizational network. For several reasons:

1. First, the 2-D lattice presented is not realistic if trying to describe an organization. The process topological structure (Ulieru, 2002) in a real-world organizational network not only communicate with their neighbors but resemble something like a small-world connectivity pattern.

2. Second, and more important, the information flow is not unidirectional or pre-defined. There are no pre-determined channels of communication or of influence that can be a-priori estimated as (Arruda-Neto et al., 2002) pretend in their model.

What seems a priori obvious, the fact that the network topology affects the percolation threshold of the network, has been later quantified in terms of percolation threshold (Lopez et al., 2007) for small-world networks and Erdo″s-Rényi networks (Bollobás, 1985).

(Jiang et al., 2009) suggest that topologyy has a weak influence on network performance, but that evolution algorithms applied to this topology can increase this performance significantly by increasing its randomness and heterogeneity. Base on this argument, my hypothesis is that the evolution of highly modular organizational networks can increase its performance by increasing its randomness and its heterogeneity.

But first we need a way to quantify our network in terms of heterogeneity, randomness and modularity. Network theorists (Solé and Valverde, 2004) propose three characteristics that define a qualitative space in order to characterize complex networks: randomness, heterogeneity and modularity.

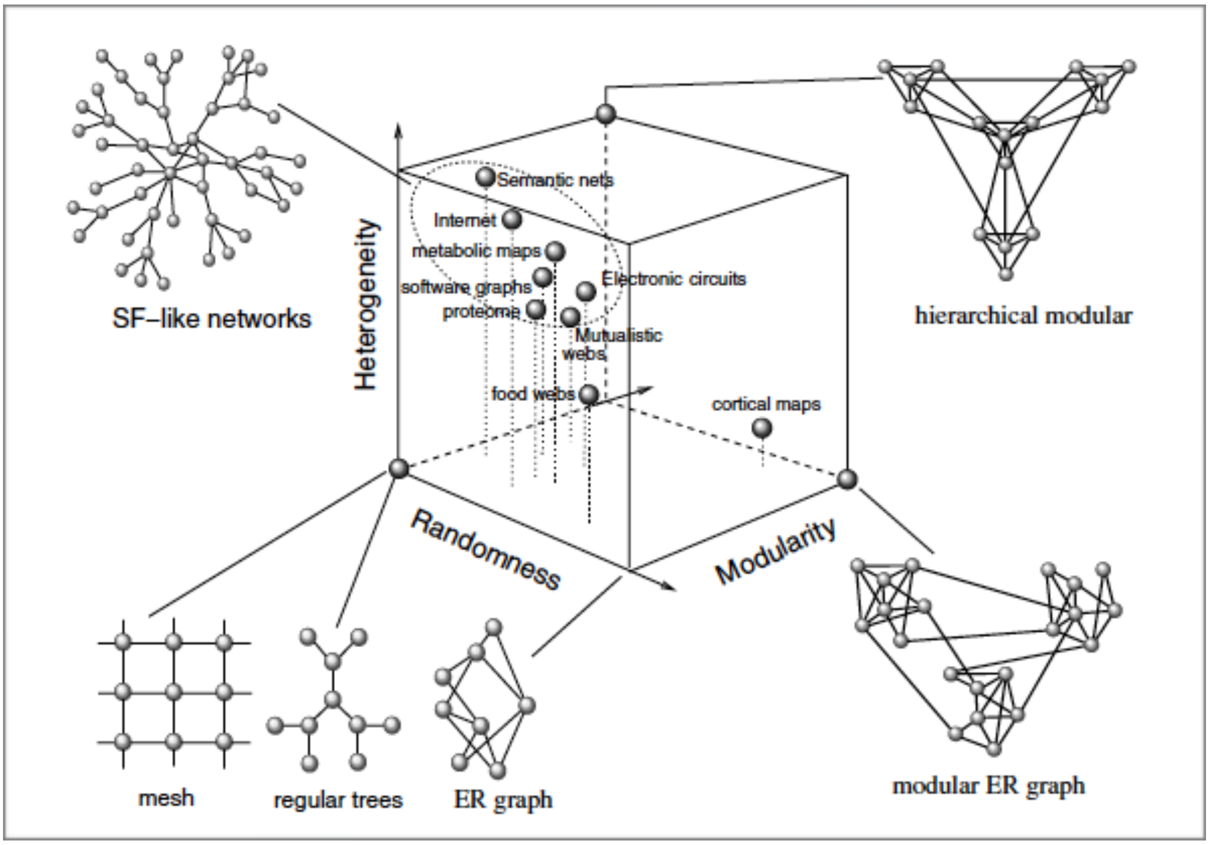


Figure 20. Classes of network architectures. Reproduced from (Solé and Valverde, 2004).

This concept has found echo between neurobiologists (Sporns, 2010) to characterize brain structures, and we intend to do the same for organizational networks.

These authors do not propose a concrete measure for the three axes. I propose following KPIs for the quantification on the 3D space defined:

- Modularity is a measure of the structure of a network. It was defined to quantify community structures in networks and graphs (Newman and Garvin, 2003). This measure is based on a measure of assortative mixing described in (Newman, 2003a). The measure proposed can be expressed as follows:

$$Q = \sum_i (e_{ii} - a_i^2) = \mathrm{Tr}\,\mathbf{e} - \| \mathbf{e}^2 \|$$

Formula (4)

where

1. e_{ij} are the elements of a kxk symmetric matrix M and represent the fraction of all edges in the network that link vertices in community i to agents in community j.
2. $a_i = \sum_j e_{ij}$ are the sum of columns (or rows)

Q delivers its maximum value of 1 if there is a strong community structure. If the number of in-community edges is not better than random, then Q will be equal to 0. The reason is that this quantity Q measures the fraction of edges in the network that connect agents of the same type minus the expected value of the same quantity in a network with the same community divisions but random connections between vertices. In practice values of Q range from 0,3 and 0,7. Higher values are rare (Newman and Garvin, 2003).

Newman and Garvin (Garvin and Newman, 2002) developed a sequential algorithm that calculates the modularity of a given network through its recursive application. The algorithm has four steps:

1. The betweenness of all existing edges in the network is calculated first.
2. The edge with the highest betweenness is removed.
3. The betweenness of all edges affected by the removal is recalculated.
4. Steps 2 and 3 are repeated until no edges remain.

Hierarchical networks are networks with a high modularity (Dorogovtsev et al., 2002) (Ravasz et al., 2002) because they are constructed of a hierarchy of different modules. The construction of such networks of high modularity happens recursively and has many similarities with the growth of fractal networks (Song et al., 2005). This is the reason why we will later use the same concept but will guide the discussion towards a - value-stream oriented - fractal network.

However is this metric not robust in terms of network size (number of nodes or number of vertices) as is shown in the following graphic for an Erdos-Renyi network and a completely regular lattice with connectivity 4.

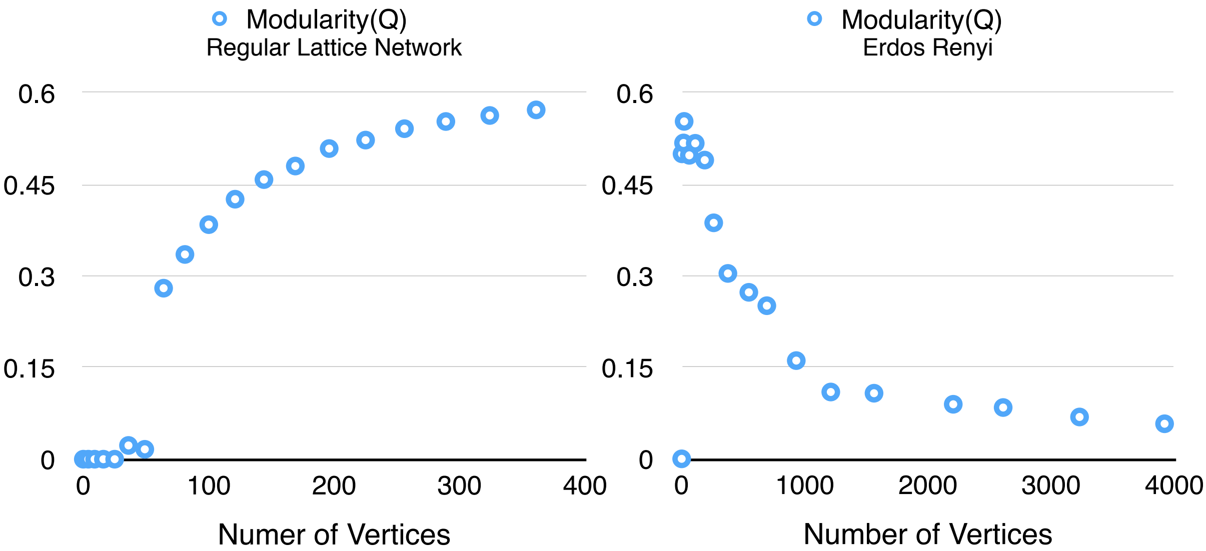


Figure 21. Robustness of Modularity (Q) with changing network size

Several researchers have used this metric in the past (Guimerà et al., 2003) (Gleiser and Danon, 2003). However, at this point of research, the question lies open if the GN modularity Q is a metric that can explain the topological structure in organizational network. The reason is that the previous graphics show that the modularity (Q) suggested by (Newman and Garvin, 2003) is not robust towards the size of the network. This can become a problem when comparing this values and trying to analyze fractal networks at different sizes. This is the reason why these metrics should be combined with algorithms that can evaluate different communities or partitions in the network such as those proposed by (Flake et al., 2002). For future research, I might however look for metrics that are fractal-robust in order to study and characterize networks.

- Heterogenity can be defined and measured for complex networks as described in (Wu et al., 2008) through the entropy of degree sequence (EDS). The authors define EDS as

$$EDS = -\frac{\sum_{i=1}^{N} D_i \ln D_i}{\sum_{i=1}^{N} D_i} + \ln\left(\sum_{i=1}^{N} D_i\right)$$

Formula (5)

where

1. D_i represent the degree of the nodes
2. and N represent the number of agents in the network.
3. The maximum value of EDS is $EDS_{max} = \log(N)$
4. The minimum value of EDS is $EDS_{min} = (\ln 4(N-1))/2$

It seems plausible that the maximum randomness is found on a random graph, thats why I reword the original paper of (Wu et al., 2008) to define NEDS (Normalized EDS) as , where they represent NEDS as a function of ERD. In the paper it´s stated that $NEDS = \frac{ERD_{\max} - ERD}{ERD_{\max} - ERD_{\min}}$, and I believe it should say:

$$NEDS = \frac{EDS_{\max} - EDS}{EDS_{\max} - EDS_{\min}}$$

Formula (6)

where

1. $EDS_{\max}$ represent the EDS of a regular lattice network
2. and $EDS_{\min}$ represent the EDS of star network where all nodes are connected with all the rest.

- Randomness can be quantified mathematically from the spectra of the adjacency matrix of the network (Ying and Wu, 2009) as Non-Randomness of a Graph as

$$\boxed{R_G = \sum_{(u,v)\in E} R(u,v)}$$

Formula (7)

where

1. $R(u,v)$ represent the non-randomness of the edge (u,v) and is expressed by
2. $R(u,v) = \sum_{i=1}^{k} x_{iu} x_{iv}$, where $(x_{1v}, x_{2v}, \ldots, x_{kv}) \in \mathbb{R}^k$ represent the spectral coordinates of the agent v.

This definition can represent randomness at all granulity levels of the organizational network and supports the fractal study of the organizational network. However is this metric not robust in terms of network size (number of nodes or number of vertices) as is shown in the following graphic for an Erdos-Renyi network and a completely regular lattice with connectivity 4.

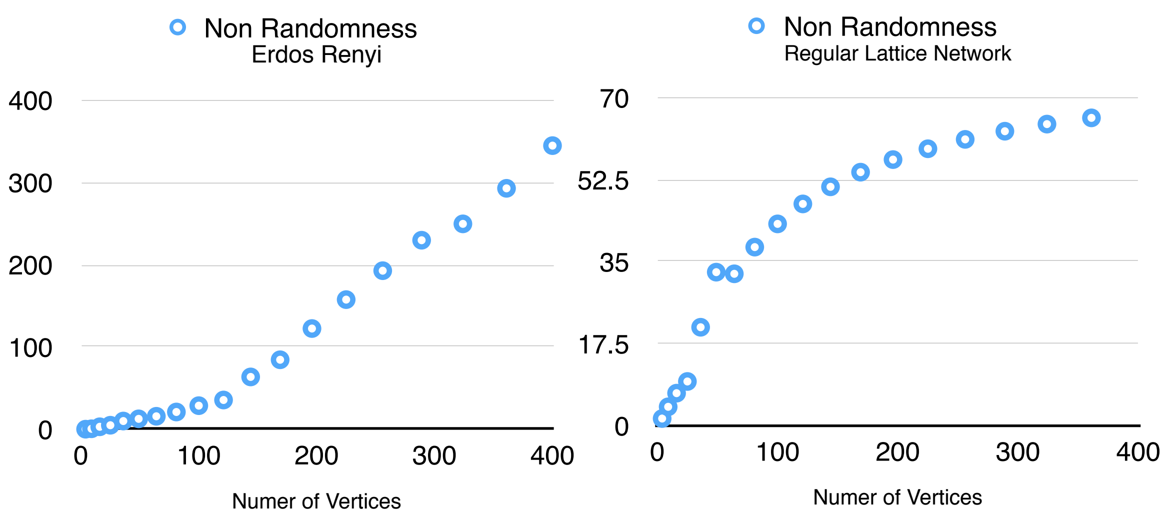


Figure 21. Robustness of Non randomness (Rq) with changing network size

It seems plausible that the maximum randomness is found on a random graph. This is the reason why (Ying and Wu, 2009) define a Normalized Non Randomness (R_G^*) as:

$$R^*_G = \frac{|R_G - E(R_G)|}{\sigma(R_G)}$$

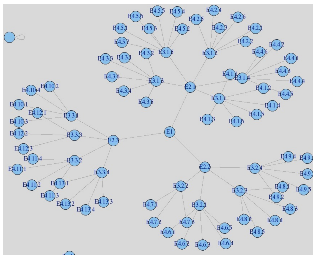
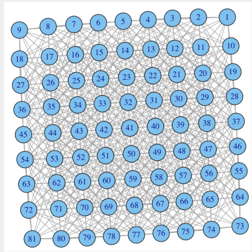
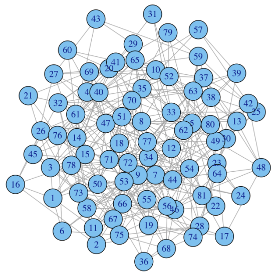
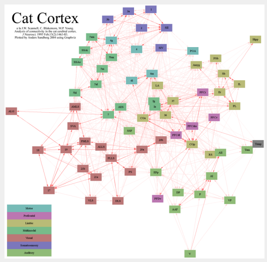
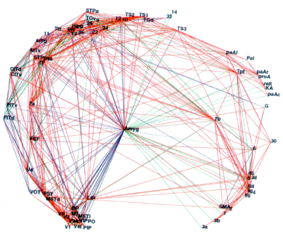
Formula (8)

where

1. $E(R_G)$ represent the expectation of non-Randomness of a large set of graphs made following the Erdos-Renyi model with a given number of nodes N, and
2. $\sigma(R_G)$ represent the standard deviation of non-Randomness of a large set of graphs made following the the Erdos-Renyi model with a given number of nodes N.

With a simple algorithm in R, after generating 500 Erdos-Renyi networks with 81 number of nodes each, we obtain that $E(R_G)$=18.11528 and $\sigma(R_G)$=2.974523.

To clarify this topics, this algorithms have been implemented into the network shown in the case study of chapter II.B as well as to several brain-like networks and to two typical networks such as a regular lattice with connectivity degree k=4 and to a classical random Erdos-Renyi (E-R) network (Erdos and Renyi, 1959) with connectivity probability of 5%, for comparison reasons. The algorithms have been coded in R and you can find the code in Appendix II.

	N	Q (Modularity)	NEDS (Heterogeneity)	R*g (Normalized Non Randomness) -after 500 iterations of ER Models -	Graph
Case Study	81	0.7794421	0.08210	3.73683	
Lattice	81	0.3353827	0.00000	6.71520	
Erdos-Renyi	81	0.4493343	0.03004	0.00000	
Connection matrices of cat cortex all cortical and thalamic areas (Scannell, 1999)	95	0.2229917	0.83164	15.35278	
Macaque Cortical Connectivity (Young, 1993)	71	0.1252728	0.88297	20.13731	

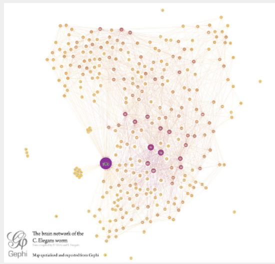
	N	Q (Modularity)	NEDS (Heterogeneity)	R*g (Normalized Non Randomness) -after 500 iterations of ER Models -	Graph
Caenorhabditis elegans worm's neural network (Watts and Strogatz, 1998)	306	0.120506	0.07818	23.84701	

Table (1). Different Networks categorized by Modularity, Heterogeneity and Non Randomness.

I observe that our Case Study network has a higher modularity Q than all other networks, but maybe this is because this network is very sparse, that´s why I increase the number of edges in the case study network by increasing the ratio number of nodes to number of edges, connecting gradually the second level of the hierarchy with the fourth so that if A is related to B, and B to C, then A is connected to C. We are creating triads or motifs in the network as described in (Sporns and Koetter, 2004).

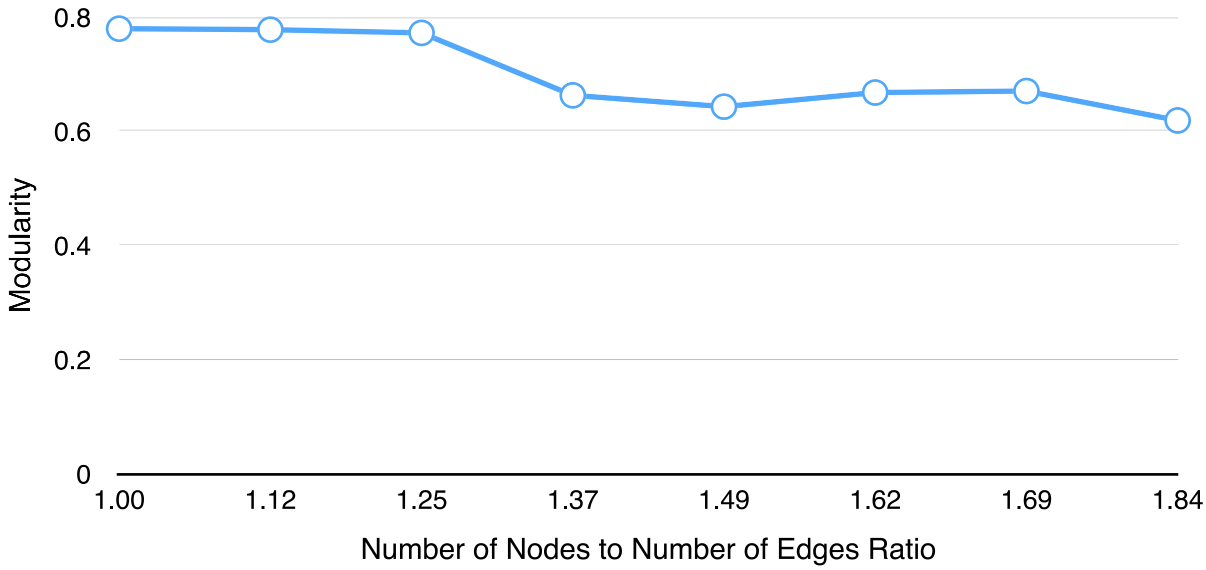


Figure 22. Robustness of Modularity with changing connectivity

This result shows that with increasing connectivity, the modularity of the network decreases. This was to be expected because modularity is a metric to measure the community structure in networks.

The heterogeneity level (NEDS) is in the same order of magnitude of a small-world network of the C.Elegans worm neutral network, higher than the Erdos-Renyi and smaller than more complex cortex connectivities. This results are consistent with the results obtained by (Kawachi et al., 2004) in which it is stated that the Entropy of a Erdos-Renyi random network is higher than that of a regular lattice, but is smaller of the entropy shown by a scale-free network.

In the next graphic, I depict, for clarity purposes, the same results in a graphical form. Here the similarity and concordance with Solé and Valverde´s (Solé and Valverde, 2004) results evident and consistent.

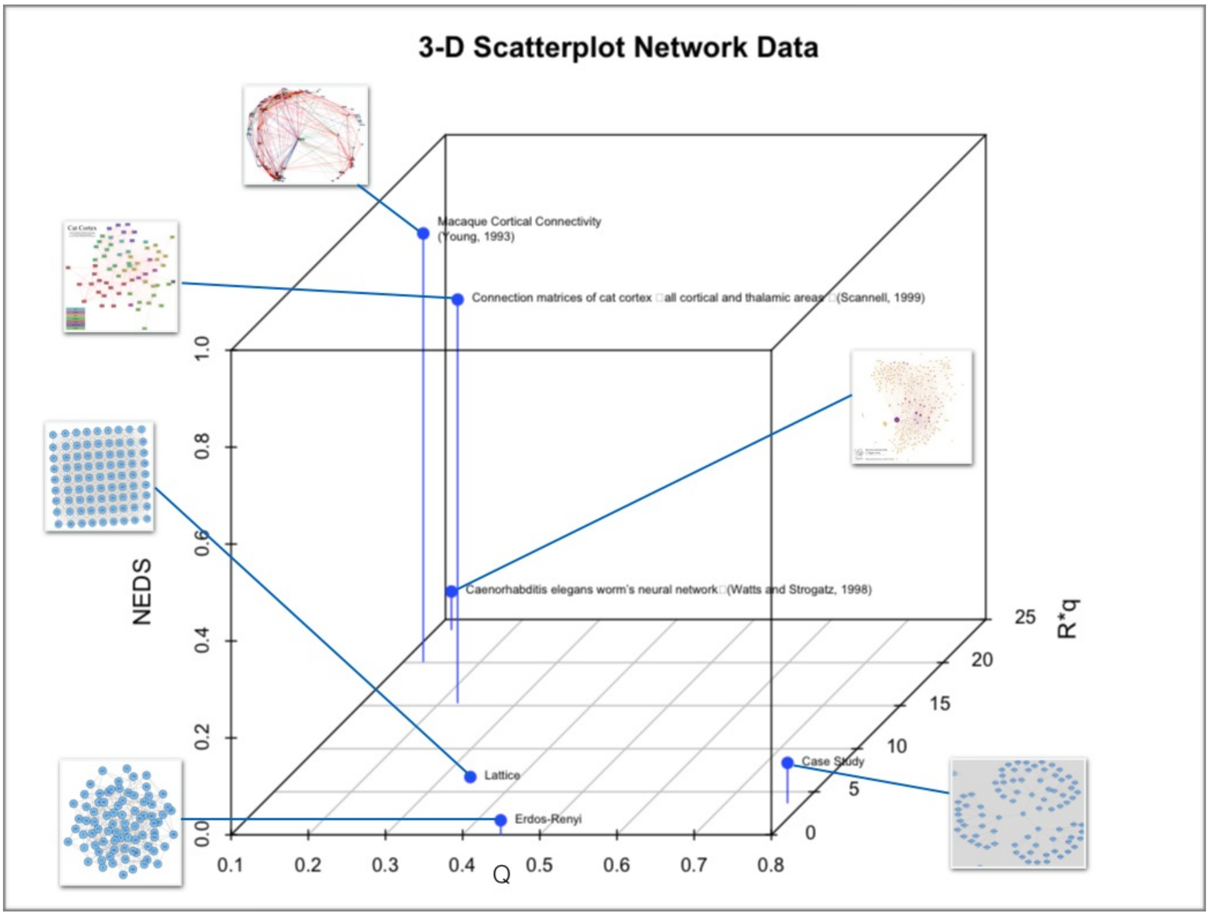


Figure 23. Graphical representation of Q, NEDS and R*q for different networks.

However, and in general, the fact that some of these metrics are dependent on the network topology is a weak point in the argumentation if we want to link network topology with other performance characteristics of the value-stream.

IV.Hoshin Kanri. Value Stream oriented Fractality.

A. Hoshin Kanri

My mentor, 福岡さん R.I.P., used to teach me that Hoshin Kanri can be translated as "Management by means". The literal translation from japanese can be broken up in parts:

Figure 24. KAIZEN Process by Fukuoka-san. (Villalba-Diez, 2013a)

- HO. 方. Means "direction".
- SHIN. 針. Means "focus".
- KAN. 管. Means "control or management".
- RI. 理. Means "meaning".

I personally translate HOSHIN KANRI as Principle Centered Leadership. Principle centered because principles are universal and are timeless (Covey, 1991) and I interpret HOSHIN this way. Leadership understood as achieving goals while increasing trust (Covey and Covey, 2008), and this is the way interpret KANRI: management through meaning. In other words, Hoshin Kanri could be translated as Leadership by giving direction.

Hoshin Kanri has been explained as the cascading of goals into the hierarchical organization, as a historically developed mix between Management by Objectives (MBO) and PDCA (Babin, 2007). I want to challenge this thought mainly because of two reasons:

1. Current management systems do not allow process owners to understand processes in its magnificent complexity and non linear dynamic. This makes it factually impossible for a policy to be rationally deployed. Authors like Hutchins (Hutchins, 2008) propose a declination from Vision and Mission-Statements going through Strategic Plans, passing through an intense analysis of Business Threats, Benchmarking, revised Targets and process control. The problem with dealing with complex systems that cannot be tackled with these "master-planning" approach. Complex systems present non-linear dynamics (Mitchell, 2009) whose agents inter-act independently in inter-dependent behaviors with the system dynamics and whose desires as well as individual goals are likely to conflict as they are intelligent and gain experience over time hence changing their bounded (Simon, 1972) but flexible behavioral strategies, all this resulting in self-organizing emergent behavioral patterns that simply cannot be designed. What I think is that the cartesian management models need to humble down their expectations and evolve to a more challenging search for guiding Principles. The reason is that complexity can only be guided, not controlled.
2. There are fundamental differences between MBO and Hoshin Kanri that make this frame of thought that Hoshin Kanri might be an evolution of MBO an oxymoron.

Management by Objectives	Hoshin Kanri
•Evaluation through Results	•Evaluation through Results and Process
•Top Down Communication	•Top-Down and Bottom-up Communication
•Directive	•Participative
•Linear „One-shot" Idea of Goal-Achievement. No Feed-back Loop.	•Circular or Spiral Idea of Goal-Achievement. Feed-back loop.
•Focus on Goals	•Focus on Goals and Process
•Focus on People Control, Ressources and Results	•Focus on the Process, Ressource Control and People Empowerment
•Primarily results oriented	•Primarily oriented to responsibility

Table (2). Management by Objectives vs. Hoshin Kanri

Hoshin Kanri is taken in previous reviews as a management method that helps managers mechanistically operationalize their goals throughout the organization.

Hoshin Kanri has been translated in past reviews as "management by policy" (Hutchins, 2008) or "policy deployment" (Cudney, 2009), understood as a rational "breakdown" of goals throughout the organization. For this purpose more or less sophisticated methods, like the A3-X (Jackson, 2006), have been developed to try to understand cross-functional relationships between projects, resources, results and business strategy. This task is in my opinion too complex and cannot be solved with such a simplistic approach. I will later in this chapter bring this again for discussion and will propose a method for approaching this task using state of the art statistical analysis.

A good review from japanese perspective of Hoshin Kanri definitions to the date of publication (1991) was given by (Akao, 1991):

(Nayatani, 1984)	Hoshin Kanri is a systematic control activity for the achievement of annual management policy based on company motto, management concepts, long/medium term plans, etc., on which all job levels perform PDCA for harmonizing each policy.
(Mizuno, 1984)	Hoshin Kanri aims to improve performance continuously by disseminating and deploying the direction, targets, and plans of company management to top management and all employees so that all job levels can act on the plans, evaluate, study and feedback results while continually performing PDCA.
(Miura, 1985)	Hoshin Kanri is all activities within an organization that aim the systematic achievement of medium/long term management plan or annual management policy, which is established as the means for achievement of management purpose
(Sugimoti, 1986)	Hoshin Kanri is a system for effective achievement of target by banding all capabilities of the total organization of the company.

Table (3). Definitions of Hoshin Kanri in (Akao, 1991)

Whatever the case, the main flaw of the previous approaches on this topic in management literature in the past has been that they all take organizational topology as a given boundary condition. Let´s discuss why.

As is shown by (Pastor-Satorras and Vespignami, 2004) there are possibilities to uncover universal growth processes in the evolution of collective behavior. Mandelbrot structures (Mandelbrot, 1982) are found everywhere in nature from snow-flakes to the coastal structure of Ireland, but being these only geometrical structures one could argue these patterns are just physical. It turns out however that similar behaviors have been found in the study of complex networks (Strogatz, 2005). This is not self evident,since the small-worldness and its exponential properties (Cohen and Havlin, 2010) have led to the general belief that complex networks are not self similar, because self similarity demands a power-law between the number of nodes and the path length (ben-Avraham and Havlin, 2000). However, fractality seems to be ubiquitous in nature and living systems. The reason for it might be the drive to gain robustness (Song et al.,2006) and the evolutional advantage it brings with it. Robustness in fractal organizations is higher than in organizations without fractal topology when other network parameters such as number of nodes, number of liks, amount of loops and clustering coefficient remain the same. Because the purpose of any organization is to create value through value streams - processes - I search for a management model that fosters and sustains network evolutionary dynamics towards value-stream oriented fractality. I dub this model HOSHIN KANRI.

It is of relevant importance to understand how the evolutional growth process of fractal structures is, because this understanding will help us develop strategies to guide organizational topologies towards desired structure. It has been shown (Song et al., 2007) that fractality in complex networks might be explained by repulsion between hubs. This implies that management theories that support the Top-Down or Bottom-up dichotomy (Kaplan, 1992) (Liker and Meier, 2006) where is more or less explicitly stated that performance management can only be successful if supported by "the boss", or the opposite that propose a bottom-up approach (Valckenaers, 1993) are plain and simply incorrect. I argue, based on the above mentioned network theory, that value-stream oriented fractality can emerge at any level of the hierarchical modular topological position in the organizational network.

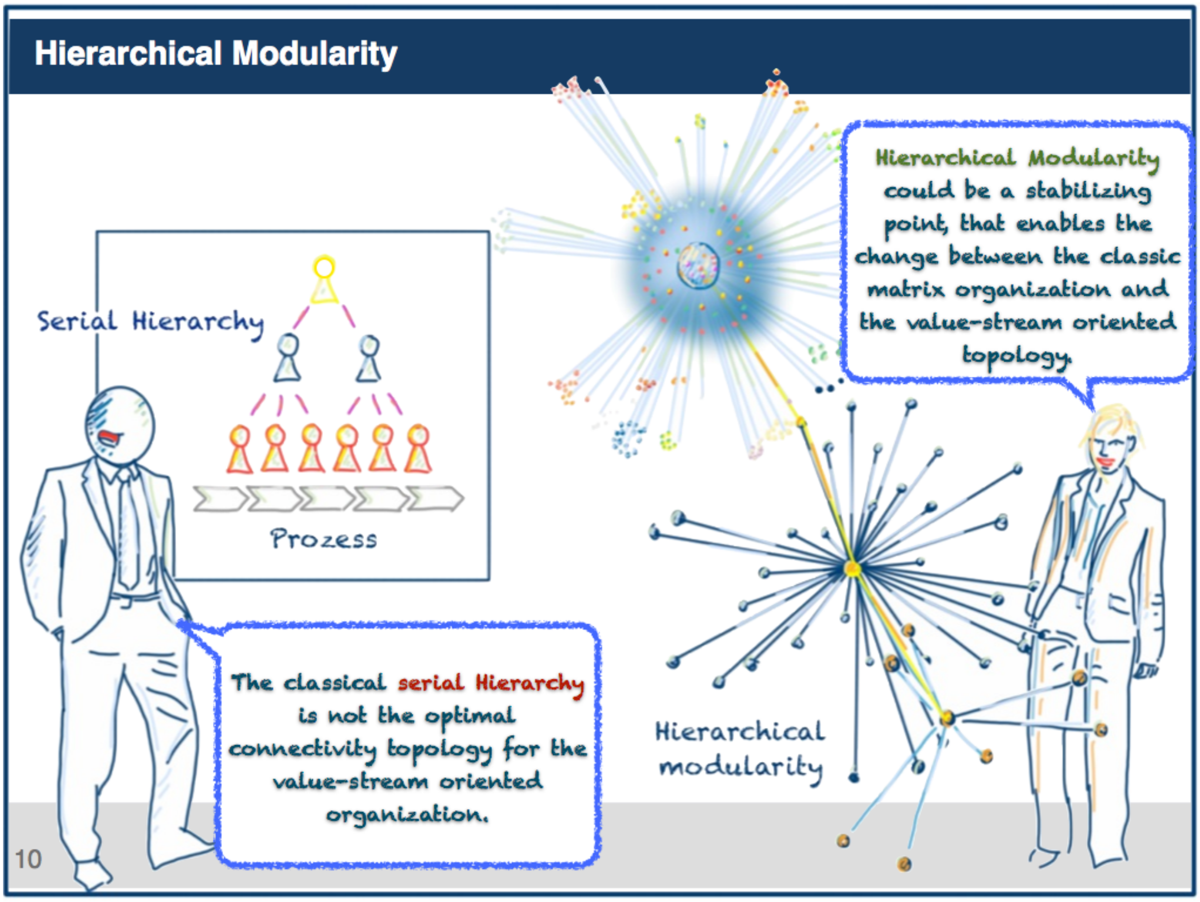


Figure 25. Hierarchical Modularity (Villalba-Diez, 2013b)

This thought is backed up by the superlative research on leadership theory from Stephen Covey (Covey, 2004) in which is states that leadership is not a matter of position but a matter of decision. This means: each and every individual in the organization can decide to act following the principles of fractality and start by acting upon the processes she owns with the fractal pattern of PDSA. These individuals will influence their organizations for a non-linear change pretty much the same way the metabolic network pattern of the yeast Escherichia coli works (Song and Makse, 2000).

Value Stream oriented fractality hence need not and can not be a priori planned. Manager's and leader's role is double:

- first set the necessary conditions (this will be trust as discussed earlier) so that the evolution of a sustainable growth can happen

- and second guide its evolution to sustain business purposes.

In the analogy of a gardener. The garden can grow without a gardener, but will not deliver what expected. The role of the gardener is then double:

- first create the necessary conditions for the lemon tree to grow healthy and give lemons,
- and second, guide the evolution of the garden (the system) in order to get the expected (business) results from the garden (the resources under her responsibility).

It lies in the nature of the garden to grow. The gardener can never control the garden. The only thing she can try to do is bring the garden in harmony with the principles of nature and serve those principles. In the same manner, the nature of any process (and the people involved) is to bring value. The Leader cannot control the process (and the people involved in it). The only thing the Leader can do is guide the process and the people towards harmony with the principles of its nature and create the necessary conditions for the process and people for sustainable value creation.

B. Evolution towards Value Stream oriented Fractality.

Based on recent network theory research (Song et al., 2006), the dynamic growth that gives rise to a fractal structure is a strong disassortativity or disassortative mixing as described in (Newman, 2004). When highly connected network agents connect to other highly connected network agents, then network theorists speak of an assortative mixing. When highly connected agents tend to connect to poorly connected agents (as in a value stream oriented connectivity pattern), then network theorists speak of dissasortative mixing or disassortativity.

A process or value-stream oriented connectivity pattern, will connect (with PDSA[4]) agents across departments, independently of the hierarchical structure of the organization. Previously poorly connected agents that only worked in their silos, will progressively be attached to more highly connected ones. For this reason it is my hypothesis that value-stream oriented connectivity patters are of dissasortative nature, and therefore my hypothesis is that organizational networks that tend to connect themselves with the fractal unit of PDSA following the value stream, will tend to develop a value-stream oriented fractality with three quantifiable characteristics:

- high modularity,
- low randomness and
- high levels of heterogeneity.

After analyzing the data shown in section II.D , my hypothesis is that the evolution of an organizational network towards a value-stream oriented fractality goes from an initial state of high modularity (Q), low entropy of degree sequence (NEDS) or heterogeneity and low non Randomness (Rq) towards a state of high modularity (Q), high heterogeneity (NEDS) and high non Randomness (Rq), and passes through topological stages that increase its non Randomness (Rq) and heterogeneity (NEDS). Furthermore, I hypothesize that the fractal states that happen throughout non linear growth are order that enable this transition (Kelso, 1995). My hypothesis is as well that losing some modularity is the price to pay in order to increase resilience (Smith, P. et al., 2011) and efficiency in the value-stream performance.

[4] It is important to remark here again, that PDSA is not only the structural unit that enables fractal and non-linear growth. It is also the behavioral pattern that enables the iterative optimization of processes, and is also the standardized communication pattern between the agents of the organizational network.

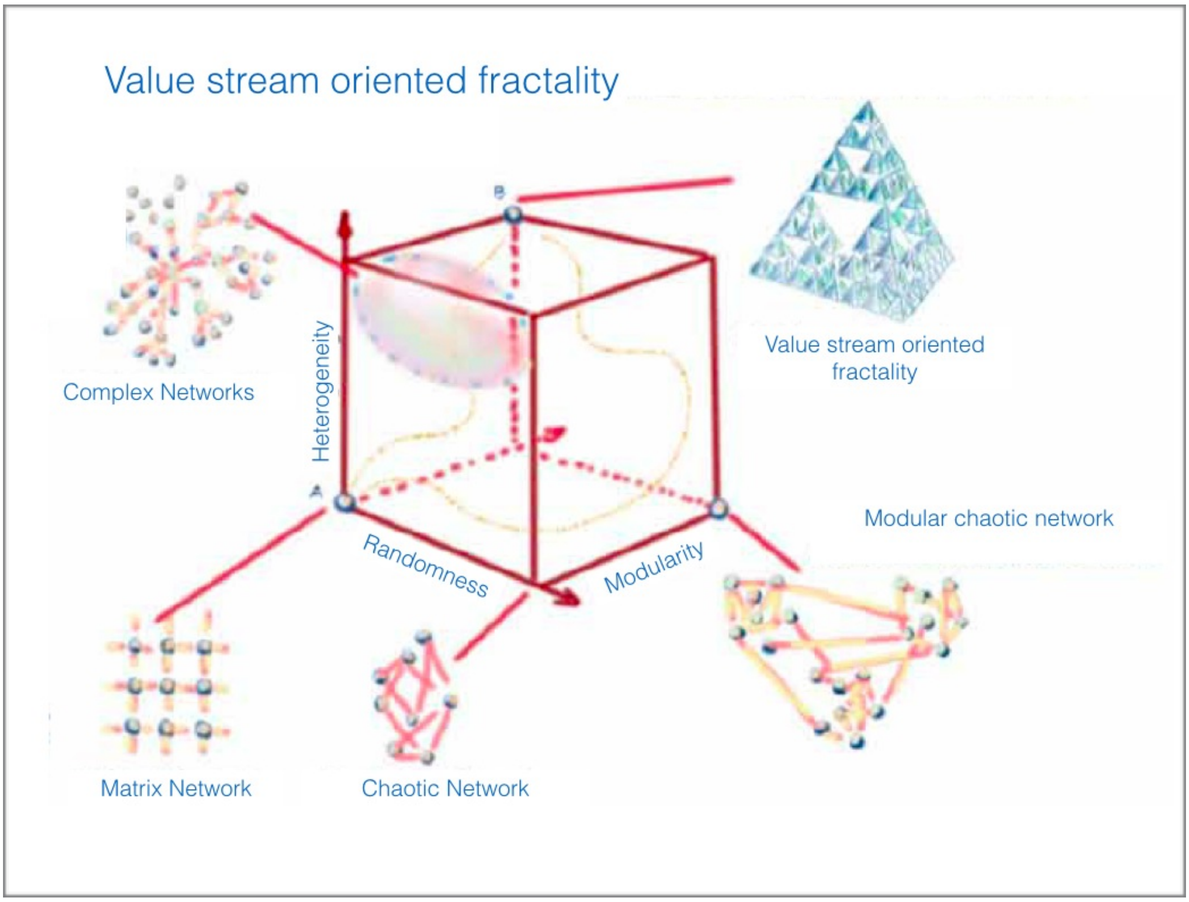


Figure 26. Value Stream Oriented Fractality.

A resilient (Smith, P. et al., 2011) modular network requires fractal topology (Song et al., 2006). But what are the evolutional drives for this specific growth patterns? This is an important question to deal with, because for evolution to happen, there must be a benefit for the system.

As the Nobel Laureate Abdus Salam put it (Salam, 1979) "nature is not economical of structures, only of principles that are of fundamental applicability". Nature likes to express itself in patterns. When we talk about patterns, we concentrate on the relationships among things. This is why I aim not only to find the optimal structure for an organization, but the principles governing the dynamics of evolution that determine the different stages of topology as well as the conditions necessary to attain such stable structures.

V. Conclusion

Summarizing, I have so far outlined several concepts. Lets put them together for clarity:

1. I build an analogy between an organizational structural topology and the brain seen as a network.

Analogy Organization and Brain	Organization	Brain Network
Vertice	Process Owner	Neuron
Edge (Channels of communication)	PDSA	Axon
Learning dynamics	Systematic repetition of PDSA leads to increased trust. (hypothesis)	Systematic repetition of tasks leads to myelinization.
Ressources	Financial, human, technological resources are allocated and distributed.	Biological ressources such as nor-adrenaline, dopamine, serotonins, … are distributed to ensure functioning.
Effect of power on functionality	May shape the channels of communication between agents (PDSA), and then have an impact on the organizational topology. (Rao et al., 2000)	Shapes behavior towards goal oriented behavior, lack of empathy, dogmatic decision making and may lead to malfunctioning of the orbit frontal cortex and lack of morality (Gruenfeld et al., 2003). This effect has been empirically tested and scientifically proved.
Structural Topology	Typically • hierarchically modular, • low randomness • and low heterogeneity.	Typically • hierarchically modular, • high randomness • and high heterogeneity.

Table (3). Analogy Organization and Brain

2. I have so far identified two organizational dimensions: process dimension and process owner dimension. Both dimensions have their topological structure and functionality.

   As shown in previous sections, I have identified non-matching structural differences between these two dimensions of an organizational topology, and my hypothesis is that this fact may lead to reduced resilience (Smith, P. et al., 2011) in the performance of the overall organizational system. As Abraham Licoln put it (Fehrenbacher, 1960) "a house divided against itself cannot stand". My hypothesis is that an organizational system divided in its core, where the topological and functional structure of the processes and of the process owners do not match, cannot deliver sustainable value creation.

In order to close this gap, I propose four steps for developing a Hoshin Kanri Management System in an Organization.

1. First I intend to find a set of three KPIs at the highest hierarchical level of the organization that describe the overall organizational performance. This KPI set will describe an inertial - in the sense of classical mechanics - 3D space. I intend to find a vector of mathematical functions that enables process owners at this level to understand the trajectory of their organization´s performance measured in this inertial 3D space as a function of the direct report KPIs*. For this purpose, I intend to find a set of three KPIs* for each direct reports that describe a non-inertial coordinate system.
2. Second, I repeat the first step recursively in all levels of the organization.
3. Third, with the help of quaternions theory and computational geometry (Kim et al., 1997), I intend to understand the dynamical and physical properties (Ordieres-Mere et al., 2012) of this holonic complex dynamic non-linear organizational structure (Iordache, 2010) and will try to systematically derive business conclusions in order to support strategic decision making and value creation. Following this method, I will be able for instance to quantify alignment in the organization.
4. Fourth. I intend to propose a universal benchmarking system that enables us to make a quantifiable comparison of management systems.

The research and practical implications might be as follow:

1. First process owners would be able to gain a systematic understanding of their organization´s structural and functional topology.
2. Second process owners would be able to understand the KPI evolution and hence be able to steer this evolutional process in any desired direction and so navigate in any given business environment.

These advantages are universal and would help any organization at any level.

VI. Closing words

Probably reality will drag me down and I will be forced to face compromises. Answers will be none or few. At the most, I expect to gain some clarity for myself, and in doing so I expect to make the reader feel the same hunger I feel when diving into these organizational theories. The thing I fear the most is getting lost in the midst of data, but I have the best advisors and mentors I could think of.

"As long as I go forward follow me, if I step back shoot me".

VII.References

Aihara, K., Matsumoto, G., 1987. Chaotic oscillations and bifurcations in squid giant axons. Chaos 257-269.

Akao, Y., 1991. Hoshin Kanri. Policy deployment for Successful TQM. Productivity Press, Cambridge.

Albert, R., Barabási, A.-L., 2002. Statistical mechanics of complex networks. Rev. Mod. Phys. 74, 47-97.

Arruda-Neto, J.D.T., Dutra, S.S., Arrais, J., Mesa, J., 2002. Physics in organizations: a percolationg approach. Contemporary Physics 43, 473-479.

Aulbach, B., Rasmussen, M., 2005. Approximation of attractors of non autonomous dynamical systems. Discrete and Continous Dynamical Systems 5, 215-238.

Ausloos, M., Dirixkx, M. (Eds.), 2006. The Logistic Map and the Route to Chaos: From the Beginnings to Modern Applications. Springer, The Neatherlands.

Avolio, B.J., Yammarino, F.J., 2013. Transformational and Charismatic Leadership: The Road Ahead, Monographs in Leadership and Management. Emerald Group Publishing Limited.

Azadegana, A., Patelb, P.C., Zangoueinezhadc, A., Lindermand, K., 2013. The effect of environmental complexity and environmental dynamism on lean practices. Journal of Operations Management 31, 193-212.

Babin, P., 2007. Hoshin Handbook, 1. ed. Total Quality Engineering, Inc., California, USA.

Balmer, J.M.T., 2001. Corporate identity, corporate branding and corporate marketing. Seeing through the fog. European Journal of Marketing 35, 248-291.

Bang-Jensen, J., Gutin, G., 2000. Digraphs: Theroy, Algorithms and Applications. Springer Verlag, London.

Banks, R.B., 1994. Growth and Diffusion Phenomena. Mathematical Frameworks and Applications. Springer, Berlin.

Beinhocker, E.E., 2006. The Origin of Wealth. Harvard Business School Press, Boston.

ben-Avraham, D., Havlin, S., 2000. Diffussion and Reactions in Fractals and Disordered Systems. Cambridge University Press.

Bennis, W.G., 1993. An Invented Life: Reflections on Leadership and Change, 1st ed. Perseus Books.
Boccaletti, S., Latora, V., Moreno, Y., Chavez, M., Hwang, D.U., 2006. Comlpex Networks Structure and Dynamics. Physical Reports 424, 175-308.
Bollobás, B., 1985. Random graphs. Academic Press, New York.
Bonham, S.S., 2008. Actionable strategies. Artech House, Boston.
Box, G.E.P., Draper, N.R., 1987. Empirical Model Building and Response Surfaces. John Wiley & Sons, New York.
Brinkmann, E., 1992. Das betriebliche Verbesserungsvorschlagswesen - Leitfaden für Arbeitnehmer und Arbeitgeber, 1st ed. Haufe, Freiburg/Berlin.
Chrystal, K. A., Mizen, Paul D., 2001. Goodhart's Law: Its Origins, Meaning and Implications for Monetary Policy.
Cohen, R., Havlin, S., 2010. Complex networks, 1st ed. Cambridge University Press, Cambridge.
Conger, J.A., Kanungo, R.N., 1998. Charismatic Leadership in Organizations (Southeastern United States), Southeastern United States. SAGE Publications, Inc.
Covey, S.M.R., Covey, S.R., 2008. The speed of trust. Free Press.
Covey, S.R., 1989. The Seven habits of highly effective people. Free Press, New York.
Covey, S.R., 1991. Principle-Centered Leadership. Simon & Schuster.
Covey, S.R., 2004. The 8th Habit. From Effectiveness to Greatness. Free Press, New York.
Coyle, D., 2009. The talent code, 1st ed. Bantam.
Cua, K.O., McKone, K.E., Schroeder, R.G., 2001. Relationships between implementation of TQM, JIT, and TPM and manufacturing performance. Journal of Operations Management 19, 675-694.
Cudney, E.A., 2009. Using Hoshin Kanri to improve the Value Stream. CRC Press, New York.
Curlee, W., Gordon, R.L., 2010. Complexity Theory and PRoject Management. John Wiley & Sons, New York.
Danielsson, J., 2002. The Emperor Has No Clothes: Limits to Risk Modelling. Journal of Banking and Finance 26, 1273-1296.

Darwin, C., 1859. The origin of species. John Murray, London.
Deming, E.W., 1964. Statistical Adjustment. Dover, New York.
Dennis, P., 2006. Getting the Right Things Done: A Leader's Guide to Planning and Execution. Lean Enterprise Insititute, Boston.
DePree, M., 1992. Leadership Jazz, The Art of Conducting Business Through: Leadership-Followership-Teamwork-Touch-Voice. Dell Publishing Co., USA.
DePree, M., 2004. Leadership is an art. Ccrown Business.
Dorogovtsev, S.N., Goltsev, A.V., Mendes, J.F., 2002. Pseudofractal scale-free web. Physical Review E 65, 066122.
Drucker, P.F., 1954. The Practice of Management, 1st ed. Harper and Brothers, New York.
Drucker, P.F., 1999. Management Challenges for the 21st Century, 1st ed. Harper- Business, New York.
Eden, D., 1992. Leadership and Expectations: Pygmalion Effects and other Self-fulfilling Prophecies in Organizations. Leadership Quarterly 3, 271-305.
Elaydi, S., Sacker, R., 2005. Global stability of periodic orbits of non autonomous difference equations and population biology. Journal Differential Equations 208, 258-273.
Erdos, P., Renyi, A., 1959. On Random Graphs I. Publicationes Mathematicae 6, 290-297.
Escher, M.C., 1953. Relativity.
Etzioni, A., 1994. Spirit of community, 1st ed. Touchstone.
Fairholm, G.W., 1991. Values Leadership: Toward a New Philosophy of Leadership. Praeger.
Fairholm, G.W., 1997. Capturing the Heart of Leadership: Spirituality and Community in the New American Workplace. Praeger.
Fairholm, G.W., 2009. Organizational power politics. ABC-CLIO, LLC, California, USA.
Fairholm, M.R., Fairholm, G.W., 2009. Understanding Leadership Perspective. Springer Science + Business Media, LLC.
Fayad, V., Rubrich, L., 2009. Policy Deployment & Lean Implementation Planning: 10 Step Roadmap to Successful Policy Deployment Using Lean as a System. WCM Associates LLC.

Fehrenbacher, D.E., 1960. The Origins and Purpose of Lincoln's "House-Divided" Speech. Mississippi Valley Historical Review 46, 615-643.
Feigenbaum, M.J., 1978. Quantitative Universality for a Class of Non-Linear Transformations. Journal Statistical Physics 19, 25-52.
Flake, G.W., Lawrence, C.L., Giles, C.L., Coetzee, F.M., 2002. Self-organization and identification of Web communities. IEEE Computer 35, 66-71.
Fogg, C.D., 2010. Team-Based Strategic Planning: A Complete Guide to Structuring, Facilitating, and Implementing the Process. CreateSpace Independent Publishing Platform.
Forrester, J.W., 1961. Industrial Dynamics. Wright-Allen Press, Cambridge.
Forrester, J.W., 1969. Urban Dynamics. MIT Press, Cambridge.
Franke, J.E., Selgrade, J.F., 2003. Attractors for discrete periodic dynamical systems. Journal of Mathematical Analysis and Applications 286, 64-79.
Frick, D.M., 2013. Implementing Servant Leadership: Stories from the Field. D.B. Reinhart Institute of Ethics in Leadership.
Fujimoto, T., 2001. Evolution of Manufacturing Systems at Toyota. Productivity Press, Portland.
Gazzaniga, M.S. (Ed.), 2000. The new cognitive neurosciences, 2nd ed, Bradford Book. MIT Press, Cambridge.
George, A., Gilbert, J.R., Liu, J.W.H., n.d. Graph Theory and Sparse Matrix Computation, 2nd ed, The IMA Volumes in Mathematics and its Applications. 2011.
Girvan, M., Newman, M.E.J., 2002. Community structure in social and biological networks. Proceedings of the National Academy of Sciences 99, 7821-7826.
Gleiser, P., Danon, L., 2003. Community structures in jazz. Preprin t cond-mat 0307434.
Goldberg, E., 2009. The New Executive Brain. frontal Lobes in a complex World. Oxford University Press, New York.
Goodhart, C., 1981. Problems of Monetary Management: The U.K. Experience. Inflation, Depression, and Economic Policy in the West 111-146.

Gragnolati, B., Stupak, R., 2002. Life and liberty: The power of positive purpose. Journal of Health & Human Services Administration 25, 75-88.
Greenleaf, R.K., Spears, L.C., Covey, S.R., 2002. Servant Leadership: A Journey into the Nature of Legitimate Power and Greatness, 3rd ed. Paullist Press, New Jersey.
Gruenfeld, D.H., Keltner, D., Anderson, C.P., 2003. The effects of power upon those who possess it: An interpersonal perspective on social cognition, in: Bodenhausen, G., Lambert, A. (Eds.), Presented at the Foundations of Social Cognition: A Festschrift in Honor of Robert S. Wyer, Jr., Erlbaum, Hillsdale, NJ.
Guimerà, R., Danon, L., Díaz-Guilera, A., Giralt, F., Arenas, A., 2003. Self-similar community structure in organisations. Physical Review E 68, 065103.
Hamacher, K., 2012. Dynamical regimes due to technological change in a microeconomical model of production. Chaos. American Institute of Physics 22, 033149-1 - 033149-6.
Hansen, R., 2001. Overall Equipment Effectiveness. Industrial Press, Inc.
Harris, R., Harris, C., Wilson, E., Womack, J.P., Jones, D.T., Shook, J., Ferro, J., 2003. Making Materials Flow: A Lean Material-Handling Guide for Operations, Production-Control, and Engineering Professionals. Lean Enterprise Insititute, Michigan, USA.
Heisenberg, W., 1927. Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik. Zeitschrift für Physik 43, 172-198.
Heppner, P.P., Wampold, B.E., Kivlighan, D.M., 2008. Research Design in Counseling, 3rd ed. Thomson.
Hopp, W. J., Spearman, M. L., 2011. Factory Physics, 3rd ed. Waveland Pr Inc.
Hutchins, D., 2008. Hoshin Kanri. The strategic approach to continous improvement. Gower Publishing Limited, Burlington.
i Cancho, R.F., Janssen, C., Sole, R.V., 2010. Topology of technology graphs: Small world patterns in electronic circuits. Physical Review E 64, 046119. doi:10.1103/PhysRevE.64.046119

Imai, M., 1986. KAIZEN: The Key to Japan´s Competitive Success. McGraw-Hill Higher Education, New York.
Iordache, O., 2010. Polystochastic Models for Complexity, Springer Complexity. Springer Verlag, Berlin.
Jackson, T.L., 2006. Hoshin Kanri for the Lean Enterprise. Productivity Press.
Jiang, F., Berry, H., Schoenauer, M., 2009. The Impact of Network Topology on Self-Organizing Maps. Presented at the Proceeding GEC '09 Proceedings of the first ACM/SIGEVO Summit on Genetic and Evolutionary Computation, ACM, New York, pp. 247-253.
Johnson, N.F., 2011. Two´s company, three is complexity, in: Simply Complexity: A Clear Guide to Complexity Theory. Oneworld Publications, Oxford.
Johnson, S., 2002. Emergence: The Connected Lives of Ants, Brains, Cities and Software. Scriber, New York.
Jones, D.T., 2011. Seeing the Whole Value Stream, 2nd ed. Lean Enterprise Insititute, Michigan, USA.
Jones, J., 2006. Integrated Logistics Support Handbook, 3rd ed, McGraw-Hill Logistics Series. McGraw-Hill Professional.
Kamada, T., Kawai, S., 1989. n algorithm for drawing gener al undirected graphs. Inform. Process. Lett. 31, 7-15.
Kaplan, R.S., 1992. The Balanced Scorecard: measures that drive performance. Harvard Business Review 71-80.
Kaplan, R.S., 2004. Strategy Maps: Converting Intangible Assets into Tangible Outcomes, 1st ed. Harvard Business Review Press.
Kaplan, R.S., Norton, D.P., 1993. Putting balanced scorecard to work 134-147.
Kaplan, R.S., Norton, D.P., 2006. Alignment, 1st ed. Harvard Business Review Press, Boston.
Kawachi, Y., Murata, K., Yoshii, S., Kakazu, Y., 2004. The structural phase transition among fixed cardinal networks, in: Proceedings of the 7th Asia-Pacific. Presented at the Conference on Complex Systems, Cairns Convention Centre, Cairns, Australia, pp. 247-255.
Kelso, S.J.A., 1995. Dynamic Patterns. The Self-Organization of Brain and Behavior. MIT Press, Cambridge.

Keltner, D., Smith, J.A., Marsh, J. (Eds.), 2010. The Compassionate Instinct: The Science of Human Goodness. W. W. Norton & Company, London.
Kim, M.-Y., Kim, M.-S., Shin, S. Y., 1997. A General Construction Scheme for Unit Quaternion Curves with Simple High Order Derivatives. ACM Transactions of graphics 16, 277-295.
Kolyada, S., Misiurewicz, M., Snoha, L., 1996. Topological entropy of non autonomous dynamical systems. Random and Computational Dynamics 4, 205-223.
Kotter, J.P., 1996. Leading Change. Harvard Business School Press.
Kouzes, J.M., Posner, B.Z., 2012. The Leadership Challenge: How to make extraordinary things happen in Organizations. Jossey-Bass.
Kudernatsch, D. (Ed.), 2013. Hoshin Kanri. Schäffer-Poeschel Verlag.
Kuroiwa, J., Miki, T., 2004. Logistic Mapping with a Time-Dependent System-Parameter and its Attractor Basins with Self-similar Structure. International Journal of Bifurcation and Chaos 14, 2407-2416.
LaGanga, L.R., 2011. Lean service operations: Reflections and new directions for capacity expansion in outpatient clinics. Journal of Operations Management 29, 422-433.
Lewin, R., 1992. Complexity: Life at the Edge of Chaos. Collier Books. Macmillan Publishing Company, New York.
Liker, J., 2004. The Toyota Way. McGraw-Hill.
Liker, J., Convis, G.L., n.d. The Toyota Way to Lean Leadership: Achieving and Sustaining Excellence through Leadership Development, 1st ed. McGraw-Hill, 2011.
Liker, J., Meier, D., 2006. The Toyota Way Fieldbook, 1st ed. McGraw-Hill.
Lopez, E., Parshani, R., Cohen, R., Carmi, S., Havlin, S., 2007. Limited path percolation in complex networks. Physical Review Letters 99, 18701-1 18701-4.
Mackelprang, A.W., Nair, A., 2010. Relationship between just-in-time manufacturing practices and performance: A meta-analytic investigation. Journal of Operations Management 28, 283-302.

Mandelbrot, B.B., 1982. The fractal geometry of nature. Freeman, San Francisco.
Martin, R.L., 2014. The big lie of strategic planning 79-84.
May, R., 1976. Simple mathematical models with very complicated dynamics. Nature 261, 459-467.
Maynard, T.H., 2010. Business Planning. Aspen Publishers.
McCann, D., Sirbasku, J., Haney, B., 2011. Leadership Charisma, 1st ed. S & H Publishing Company LLC.
McCarney, R., Warner, J., van Haselen, R., Griffin, M., Fischer, P., 2007. The Hawthorne Effect: a randomised, controlled trial. BMC Med Res Methodol 7.
Metropolis, N., Stein, P.R., 1973. On finite limit sets for transformations on the unit interval. Journal Combinatory Theory 15, 25-44.
Meunier, D., Lambiotte, R., Fornito, A., Ersche, K.D., Bullmore, E.T., 2009. Hierarchical modularity in human brain functional networks. Frontiers in Neuroinformatics 3, 1-12.
Mintzberg, H., 1985. Of strategies, deliberate and emergent. Strategic Management Journal 6, 257-272.
Mintzberg, H., 1998. Strategy Safari. Free Press.
Mitchell, M., 2009. Complexity: A guided Tour, 1st ed. Oxford University Press, New York.
Mitchell, M., 2011. Complexity. A Guided Tour. Oxford University Press, New York.
Miura, S. (Ed.), 1985. TQC Terminology Dictionary. Japan Standards Association.
Mizuno, S., 1984. Companywide Overall QC. Nikka-Giren.
Moore, C., Newman, M.E.J., 2000. Epidemics and percolation in small-world networks. Phys. Rev. E. 61, 5678-5682.
Morrow, J.D., 1994. Game Theory for Political Scientists. Princeton University PRess, Princeton.
Nash, J.E., 1950. Equilibrium points in n-person games. Proceedings of the National Academy of Sciences 48-49.
Nash, J.E., Sutcliffe, J.V., 1970. River flow forecasting through conceptual models part I. Journal of Hydrology 10, 282-290.
Nayatani, Y., 1984. Way of looking and thinking of things. JUSE.

Neßler, C., Fischer, M.-T., 2013. Social Responsive Balanced Score Card. Springer Gabler, Wiesbaden.
Newman, M.E.J., 2003a. Mixing patterns in networks. Physical Review 67, 026126.
Newman, M.E.J., 2003b. The structure and function of complex networks. SIAM 45, 167-256.
Newman, M.E.J., 2004. Coauthorship networks and patterns of scientific collaboration. Coauthorship networks and patterns of scientific collaboration 101, 5200-5205.
Newman, M.E.J., 2006. Modularity and community structure in networks. PNAS 103, 8577-8582.
Newman, M.E.J., Girvan, M., 2004. Finding and evaluating community structure in networks. Physical Review. E. Statistical Nonlinear Soft Matter Physics. 69, 026113.
Norris, J.R., 1998. Markov Chains. Cambridge University Press, Cambridge.
Ohno, T., 1988. Toyota Production System: Beyond Large Scale Production. Productivity Press, Portland.
Ordieres-Mere, J., Bello-Garcia, A., Gonzalez-Marcos, A., 2012. . International Journal Vehicle Design 59, 249-271.
Papageorgiou, E.I., Stylios, C.D., 2008. Fuzzy cognitive maps, in: Pedryck, W., Skowron, A., Kreinovich, V. (Eds.), Handbook of Granular Computing. John Wiley & Sons.
Parmenter, D., 2010. Key Performance Indicators (KPI): Developing, Implementing, and Using Winning KPIs, 2nd ed. Willey.
Pastor-Satorras, R., Vespignami, A., 2004. Evolution and Structure of the Internet: A Statistical Physics Approach. Cambridge University Press, Cambridge.
Pfeffer, J., 2010. Power: why some people have it and others don´t, 1st ed. Harper Collins Ebooks.
Rao, H., Morrill, C., Zald, M.N., 2000. Power Plays: How Social Movements and Collective Action Create new Organizational Forms. Research in Organizational Behaviour, Elsevier Science Inc., 237-281.
Ravasz, E., Somera, A.L., Mongru, D.A., Oltvai, Z.N., Barabási, A.-L., 2002. Hierarchical organization of modularity in metabolic networks. Science 297, 1551-1555.

REFA Verband, 1985. Methodenlehre des Arbeitsstudiums: Teil 3 Kostenrechnung, Arbeitsgestaltung. Hanser, München.
Robinson, S.W., 2007. Corporate Espionage 201. SANS Institute 12.
Rodriguez, R.R., Alfaro, J.A.S., Ortiz, A.B., Verdecho, M.J.S., 2010. Identifying relationships between key performance indicators.
Rother, M., 2009. Toyota Kata: Managing People for Improvement, Adaptiveness and Superior Results, 1st ed. McGraw-Hill.
Rother, M., Harris, R., 2001. Creating Continuous Flow: An Action Guide for Managers, Engineers & Production Associates, 1st ed. Lean Enterprise Insititute, Michigan, USA.
Rother, M., Shook, J., Womack, J., Jones, D., 1999. Learning to See: Value Stream Mapping to Add Value and Eliminate MUDA, 1st ed. Lean Enterprise Insititute, MI, USA.
Rubinov, M., Sporns, O., 2010. Complex network measures of brain connectivity: Uses and interpretations. Neuroimage 52, 1059-1069.
Salam, A., 1979. Gauge unification of fundamental forces.
Saynisch, M., 2010. Beyond Frontiers of Traditional Project Management: An Approach to Evolutionary, Self-Organizational Principles and the Complexity Theory - Results of the Research Program. Project Management Journal 41, 21-37.
Scannell, J.W., Burns, G.A., Hilgetag, C.C., O'Neil, M.A., Young, M.P., 1999. The Connectional Organization of the Cortico-thalamic System of the Cat. Cerebral Cortex 9, 277-239.
Schuster, H.-G. (Ed.), 2009. Reviews of Nonlinear Dynamics and Complexity. Wiley-VCH Verlag GmbH & Co. KGaA.
Senge, P.M., 1990. The fifth discipline. The Art and practice of The Learning Organization. Business Books, London.
Shah, R., Ward, P.T., 2003. Lean manufacturing: context, practice bundles, and performance. Journal of Operations Management 21, 129-149.
Shah, R., Ward, P.T., 2007. Defining and developing measures of lean production. Journal of Operations Management 25, 785-805.

Shi, J., 2012. Chaos in Nonautonomous Discrete Dynamical Systems Approached by their Induced Systems. International Journal of Bifurcation and Chaos 22, 1250284-1 -1250284-12.
Simon, H.A., 1962. The Architecture of Complexity. Proceedings of the American Philosophical Society 106, 467-482.
Simon, H.A., 1972. Theories of bounded Rationality, in: McGuire, C.B., Radner, R. (Eds.), Decision and Organizations. North-Holland Publishing Company, pp. 161-176.
Smalley, A., 2004. Creating Level Pull: A Lean Production-System Improvement Guide for Production-Control, Operations, and Engineering Professionals, Lean Tool Kit. Lean Enterprise Insititute, Michigan, USA.
Smith, P., Hutchison, D., Sterbenz, J.P.G., Schöller, M., Fessi, A., Karaliopoulos, M., Lac, C., Plattner, B., 2011. Network resilience: a systematic approach. IEEE Communications Magazine 49, 88-97.
Sobek II., D.K., Smalley, A., 2008. Understanding A3 Thinking: A Critical Component of Toyota's PDCA Management System, 1st ed. Productivity Press.
Solé, R.V., Valverde, S., 2004. Information Theory of Complex Networks: On Evolution and Architectural Constraints. Lect. Notes Phys. 650, 189-207.
Solomon, S., Weisbuch, G., de Arcangelis, L., Naeem, J., Stauffer, D., 2000. Social percolation models. Physica A 207, 239-247.
Song, C., Gallos, K., Makse, H.A., 2007. How to calculate the fractal dimension of a complex network: the box covering algorithm. Journal of statistical mechanics: Theory and Experiment P03006.
Song, C., Havlin, S., Makse, H.A., 2005. Self-similarity of complex networks. Nature 433, 392-395.
Song, C., Havlin, S., Makse, H.A., 2006. Origins of fractality in the growth of complex networks. Nature Physics 2, 275-281.
Song, C., Makse, H.A., 2006. Emergence of modularity in the evolution of the yeast protein-protein interaction network.
Sousa, R., Voss, C.A., 2001. Quality management: universal or context dependent? Production and Operations Management 10, 383-404.

Spitzer, D.R., 2007. Transforming Performance Measurement: Rethinking the Way We Measure and Drive Organizational Success. AMACON.

Sporns, O., 2010. Networks of the Brain. MIT Press, Boston.

Sporns, O., 2012. From simple graphs to the connectome: Networks in neuroimaging. Neuroimage 62, 881-886.

Sporns, O., Koetter, R., 2004. Motifs of the brain. PLos Biology 2, 1910-1918.

Sporns, O., Tononi, G., Kötter, R., 2005. The human connectome: A structural description of the human brain. PLosP Comput Biol 1, 245-251.

Staats, B.R., Brunner, D.J., Upton, D.M., 2011. Lean principles, learning, and knowledge work: Evidence from a software services provider. Journal of Operations Management 29, 376-390.

Sterman, J.D., 2000. Business Dynamics. Systems Thinking and Modeling for a Complex World. Irwin McGraw-Hill, Boston.

Stiskin, N., 1972. The looking-glass god: Shinto, Yin-yang, and a cosmology for today, 1st ed. Autum Press, New York.

Strogatz, S.H., 2001. Exploring Complex Networks. Nature 410, 268-276.

Strogatz, S.H., 2005. Complex systems: Romanesque networks. Nature 433, 365-366.

Sugimoti, T. (Ed.), 1986. QC of Clerical-Sales Service Work. Nippon Kikaku Kyokai.

Sullivan ,L., 1896. The Tall Office Building Artistically Considered. Lippincott´s Magazine 403-409.

Thoreau, H.D., 2004. Walden: A Fully Annotated Edition. Yale University Press.

Tsunemoto, Y., 1979. Hagakure: The Book. Shambhala.

Ulieru, M., 2002. Emergence of Holonic Enterprises from Multi-Agent Systems: A Fuzzy Evolutionary Approach, in: Loia, V. (Ed.), Soft Computing Agents. IOS Press, Amsterdam, pp. 187-215.

Ulrich, D., Zenger, J., Smallwood, N., 1999. Results-Based Leadership, 1st ed. Harvard Business Review Press.

Vaill, P.B., 1991. Managing as a Performing Art: New Ideas for a World of Chaotic Change, 1st ed. Jossey-Bass.

Vaill, P.B., 1996. Learning as a Way of Being: Strategies for Survival in a World of Permanent White Water, 1st ed. Jossey-Bass.

Valckenaers, P., 1993. Flexibility for Integrated Production Automation.

van Brussel, H., Bongaerts, L., Wyns, J., Valckenaers, P., van Ginderacter, T., 1999. A Conceptual Framework for Holonic Manufacturing: Identification of Manufacturing Holons. Journal of Manufacturing Systems 18, 35-52.

van Steen, M., n.d. Graph Theory and complex Networks. An Introduction. van Steen.

van Wijk, B.C.M., Stam, C.J., Daffertshofer, A., 2010. Comparing Brain Networks of Different Size and Connectivity Density Using Graph Theory. PLoS ONE 5.

Verhulst, P.F., 1847. Deuxi`eme m´emoire sur la loi d'accroissement de la population. M´em. de l'Acad´emie Royale des Sci. des Lettres et des Beaux-Arts de Belgique 20, 1-32.

Villalba-Diez, J., 2013a. Hoshin Kanri. Yokoten 1-16.

Villalba-Diez, J., 2013b. Lean Brain. Yokoten 1-16.

Wakeman, C., Winget, L., 2010. Reality-Based Leadership: Ditch the Drama, Restore Sanity to the Workplace, and Turn Excuses into Results, 1st ed. Jossey-Bass.

Watts, D.J., Strogatz, S.H., 1998. Collective dynamics of "small-world" networks. Nature 393, 440-442.

Wheatley, M.J., 164AD. Leadership and the New Science: Learning about Organization from an Orderly Universe, 1st ed. Berret-Koehler Publishers.

Wiegand, B., Franck, P., 2004. Lean Administration I: So werden Geschäftsprozesse transparent. Schritt 1: Die Analyse. Workbook, 1st ed. Lean Management Institut.

Womack, J.P., Jones, D.T., 1996. Lean Thinking. Free Press, New York.

Womack, J.P., Jones, D.T., Roos, D., 1990. The Machine That Changed the World. Harper Perennial, New York.

Wood, S.J., Stride, C.B., Wall, T.D., Clegg, C.W., 2004. Revisiting the use and effectiveness of modern management practices. Human Factors and Ergonomics 14, 413-430.

Wright, F.L., 2005. Frank Lloyd Wright: An Autobiography. Pomegranate Communications.
Wu, J., Tan, Y.-J., Deng, H.-Z., Zhu, D.-Z., 2009. A new measure of heterogeneity of complex networks based on degree sequence, in: Minal, A.A., Braha, D., Bar-Yam, Y. (Eds.), Unifying Themes in Complex Systems. Spinger, Berlin Heidelberg, pp. 66-73.
Ying, X., Wu, X., 2009. On Randomness Measures for Social Networks. SIAM Conference on Data Mining 709-720.
Young, M.P., 1993. The organization of neural systems in the primate cerebral cortex. Proceedings of the Royal Society B, 13-18.
Zhou, Z., Zou, X., 2003. Stable periodic solutions in a discrete periodic logistic equation. Applied Mathematics Letters 16, 165-171.
Zohar, D., 2000. SQ: Connecting With Our Spiritual Intelligence, 1st ed. Bloomsbury, USA.
馬場文雄, 2012. PDCA サイクルをベースとした 安定的設備保全活動に関する研究。横浜国際社会科学研究 17.

VIII. Appendix II.
R Code for Modularity, Heterogeneity and Non Randomness

```
#First Network Case Study PDSA Network

edges <- read.csv("/Users/.../test.csv", header = TRUE,sep=";")
pdsa.network<-graph.data.frame(edges[,c(2,1)], directed=TRUE)
plot(pdsa.network, layout=layout.kamada.kawai)

#Second Network Regular Lattice Network

lattice <- graph.lattice( c(9,9) )
lattice <- connect.neighborhood(lattice, 4)
plot(lattice)

#Third Network Erdos Renyi Network with probability of connection 5%

ErdosRenyi <- erdos.renyi.game(81, 0.05, type=c("gnp", "gnm"), directed =
FALSE, loops = FALSE)
plot(ErdosRenyi)

#Fourth Network Macaque Cortical Connectivity (Young, 1993)

edges <- readMat("/Users/.../macaque71.mat")
macaque71<-graph.data.frame(edges, directed=TRUE)

#Fifth Network Connection matrices of cat cortex all cortical and thalamic
areas

edges <- readMat("/Users/.../cat.mat", header = TRUE,sep=";")
cat<-graph.data.frame(edges[1], directed=TRUE)

#Sixth Network The Caenorhabditis elegans worm's neural network (Watts and
Strogatz, 1998)

worm <- read.table("http://opsahl.co.uk/tnet/datasets/celegans_n306.txt")

# Function calculating the modularity of the network

modularity=function(net) {
Q <- edge.betweenness.community(net)
return(max(Q$modularity))
}

# Normalized Entropy Degree Sequence. NEDS Heterogeneity

N<-81
net<-graph.data.frame(edges, directed=F)
d1 <- degree(net, mode="in")
```

```
d1 <- d1[d1 != 0]
d2 <- log(d1)
EDS <- -((sum (d1*d2))/sum (d1)) + log (sum(d1))
lattice <- graph.lattice( c(floor(sqrt(N)),floor(sqrt(N))) )
lattice <- connect.neighborhood(lattice, 4)
sg<-star.graph(N)
EDSMAX<- EDS(lattice)
EDSMIN<- EDS(sg)
NEDS <- (EDSMAX-EDS)/(EDSMAX-EDSMIN)

# Function calculating Non Randomness as described in (Ying and Wu, 2009) -
code by Joaquin Ordieres Mere -

nonRandomness=function(net) {
  fR=function(x,vec,k) {
    return(sum(vec[as.numeric(x[1]),1:k]*vec[as.numeric(x[2]),1:k]))}
  A=get.adjacency(net)
  eig=eigen(A)
  ebc=edge.betweenness.community(net,
           directed=TRUE,modularity=TRUE)
  k=max(ebc$membership)
  nodes=V(net)$name
  if (is.null(nodes)) {
    nodes=V(net)}
  edgel = get.edgelist(net)
  ednel = edgel
  ednel[,1]=as.numeric(match(edgel[,1],nodes))
  ednel[,2]=as.numeric(match(edgel[,2],nodes))
  return(sum(apply(ednel,1,fR,eig$vectors,k)))
}

# 3D Scatterplot representation of networks

A <- read.csv("/Users/.../3d_scatterplot_networks.csv")

a0<-as.vector(A[1])
a1<-as.vector(A[3])
a2<-as.vector(A[4])
a3<-as.vector(A[5])
s3d <- scatterplot3d(a1[,1], a2[,1], a3[,1],  # x y and z axis
  color="blue", pch=19, # filled blue circles
  type="h",             # lines to the hor-zontal plane
  main="3-D Scatterplot Network Data",
  xlab="Q",
  ylab="NEDS",
  zlab="R*q")
s3d.coords <- s3d$xyz.convert(a1[,1], a2[,1], a3[,1]) # convert 3D coords
to 2D projection
   text(s3d.coords$x, s3d.coords$y, # x and y coordinates
        labels=(a0[,1]), # text to plot
        cex=.5, pos=4) # shrink text 50% and place to right of points)
```